Commonwealth Energy Biogas/PV Mini-Grid Renewable Resources Program

Making Renewables Part of an Affordable and Diverse Electric System in California

Contract No. 500-00-036

BI-PV and Biogas Market Potential Assessment Final Report

Project No. 1.1 Program Planning and Analysis

Task 1.1.7 Final Report

Prepared For:
California Energy Commission
Public Interest Energy Research Renewable Program

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Introduction

This report summarizes the methods and findings of a study to assess the market potential for non-residential renewable distributed generation, utilizing biogas and building-integrated photovoltaics (BI-PV) within the Chino Basin located southeast of Los Angeles in Southern California. Regional Economic Research, Inc., a wholly owned subsidiary of Itron, Inc. (Itron/RER), conducted the study for the California Energy Commission (Commission) under Contract No. 500-00-036. This assessment comprises one element of the broader Commonwealth Energy Biogas/PV Renewable Mini-Grid Program (Program) being administered through the Commission's Public Interest Energy Research (PIER) Renewables group. The overall purpose of the broader PIER Program is to increase the market opportunities, the available technologies, and the affordability of renewable energy options in California.

1.1 Overview of Commonwealth PIER Program Planning and Analysis Project

The Commonwealth Program's initial research, development and demonstration activities include two parallel efforts to help refine the Program strategy and direction: 1) Program Planning and Analysis (Project 1.1), and 2) Building-Integrated Photovoltaics (BI-PV) Testing and Evaluation (Project 3.2). The primary objectives for the Commonwealth PIER Project 1.1, Program Planning and Analysis effort, are to:

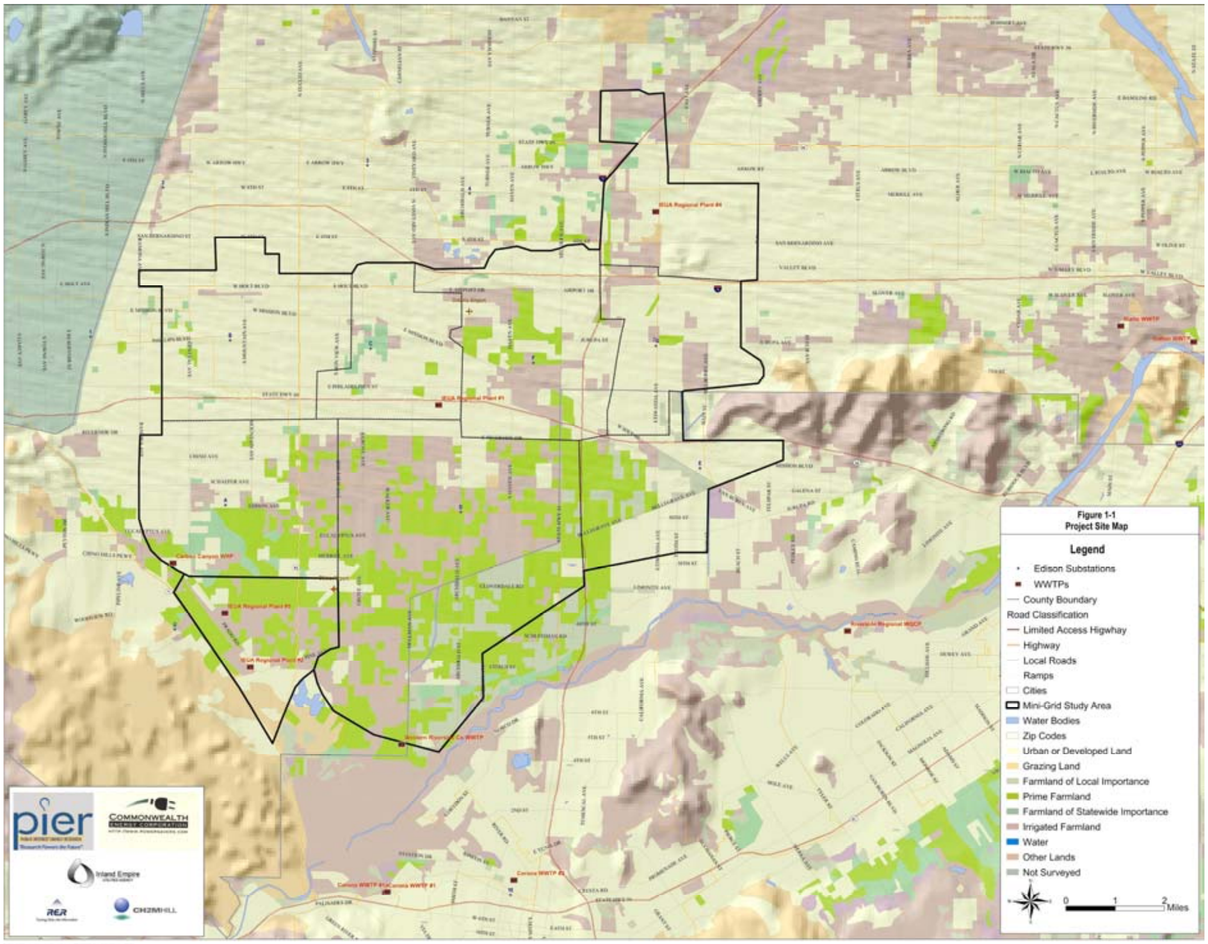
- Define the initial Program study area,
- Inventory the study area's potential photovoltaic and biogas resources to assess the potential of such resources and to help identify potential demonstration projects,
- Identify a mini-grid, on which the potential distribution impact of the development of such resources can be assessed,
- Conduct power flow studies to identify and quantify the benefits of various levels of renewable energy penetration on the local electric distribution system,
- Identify and prioritize individual demonstration projects, and
- Identify net cost savings and benefits that would accrue by developing complementary resources.

A multidisciplinary team led, by Itron/RER and supported by CH_2M Hill, Renewable Energy Development Institute (REDI) and Zaininger Engineering Company (ZECO), is responsible for meeting these program-planning objectives. CH_2M Hill is responsible for undertaking the various biogas resource inventory assessments. Electric system characterization and data development, power flow and other studies related to the mini-grid are being undertaken by ZECO. As mentioned above, the nonresidential BI-PV resource assessment documented in this report is being performed jointly by the REDI and Itron/RER.

1.2 Market Potential Assessment Objectives

This report focuses on the assessment of existing and future biogas and non-residential BI-PV market potential in the subject area, which is in the Chino Basin located east-southeast of Los Angeles. The boundaries of the Commonwealth PIER Renewables Program "mini-grid" encompass area in the southwest portion of San Bernardino County and the northwest portion of Riverside County. Initial specification of a *preliminary* mini-grid boundary was previously completed under Task 1.1.1 of the Program. A map outlining the geographical area of the Commonwealth Renewables electric distribution system mini-grid is included in Figure 1-1.

Figure 1-1: Commonwealth Renewables Mini-grid Map



The general goals of this market potential assessment are to:

- Develop an understanding of the renewable distributed generation resources that could be expected to contribute to electric grid support, both currently and over the 10 year planning period, and
- Provide renewable distributed generation market potential information to the T&D power flow expansion case modeling effort.

The specific objectives of this Task 1.1.7 market potential assessment include:

- Estimate the economic potential (in MW) for each Commonwealth Program biogas and BI-PV resource in 2003, 2007 and 2012 within the mini-grid, and
- Estimate the market potential (in MW) for each biogas and BI-PV resource in 2003, 2007 and 2012 within the mini-grid.

The specific biogas resources examined in this effort include landfill gas, agricultural (dairy) and food processing waste digester gas, and wastewater treatment digester gas. The non-residential BI-PV systems evaluated under this assessment include rooftop, curtain wall, awning, and parking/shade structure applications. The resulting market potential estimates for these biogas and non-residential BI-PV resources feed into the power flow modeling in Task 1.1.9b of the Program Planning and Analysis Project, which are necessary in order to quantify the grid impacts. The prior estimation of biogas technical potential was completed under Task 1.1.2, Task 1.1.3, and Task 1.1.4 of the Program.

Translation of the previous estimates of biogas and BI-PV technical potential under Tasks 1.1.2 through 1.1.5 into estimates of market potential are documented here under this Task 1.1.7 deliverable of the Commonwealth PIER Renewables Mini-grid Program. The scope of this market potential assessment was limited to maintain focus on areas that are most germane to the Commonwealth PIER Program. Therefore, only *non-residential* market applications within the Commonwealth Program mini-grid area are considered in this assessment.

1.3 Report Organization

Section 2 of this report provides a general overview of the methodology used in the assessment of market potential. The introductory overview includes a description of issues surrounding the market conditions that affect the adoption of biogas and BI-PV renewable distributed generation systems. Sections 3 through 6 provide descriptions of the BI-PV, dairy and food waste, wastewater treatment, and landfill gas resource market potential assessments, respectively. Within each of these sections, major issues are addressed surrounding the economic and market conditions that affect the adoption of the three biogas and the nonresidential BI-PV renewable generation systems. Section 7 provides a summary of the overall results of this market assessment.

2

Overview of Analytic Methodology

2.1 Introduction

The principal objective of the effort summarized in this Project 1.1 report is to estimate the quantity of nonresidential renewable energy capacity that can be expected to influence future electrical distribution infrastructure operations and potential expansion requirements within the Program mini-grid area. These expected quantities of renewable generation are referred to as the market potentials of these technologies. Market potential represents a level of technology deployment based on an assumed combination of conditions influencing the costs, benefits, market/deployment barriers, and perceptions of the technology.

The difference between market potential and technical potential is that market potential is constrained not only by technical factors, but also by economic, market (e.g., existence of and access to qualified vendors/installation firms), and other human (e.g., decision-maker perceptions of risk) factors. An intermediate result in the market potential analysis is economic potential. Economic potential refers to the portion of technical potential that could be developed cost-effectively. Detailed discussion of the basis of the several types of electric generation potential follows below.

2.2 Definition of Relevant Terms

A variety of terms are used in the analysis of economic and market potential of the several technologies covered by this project. These key terms are introduced and described below.

- ***Gross Technical Potential.*** This is the amount of renewable energy system capacity that could be installed if it were utilized in all applications in which it could technically be adopted, without consideration of cost-effectiveness or other market-related barriers.
- ***Net Technical Potential.*** This is the portion of gross technical potential remaining to be pursued after accounting for existing renewable energy system capacity.
- ***Economic Potential.*** This is the cost-effective portion of the net technical potential.

- ***Incremental Market Potential.*** This is the amount of renewable energy system capacity that can be installed cost-effectively in any given year, given existing market circumstances.
- ***Cumulative Market Potential.*** This is the "running total" across years of renewable energy system capacity that are expected to be developed and remain operational.

2.3 Technical Potential

Market potential represents a subset of economic potential, which in turn represents a subset of technical potential. Estimation of market potential is therefore accomplished sequentially. The analysis begins with technical potential estimates yielded by previous Project Tasks 1.1.2 through 1.1.5 of this Program Planning and Analysis Project. The summary reports for these tasks are identified in Table 2-1. Results of these tasks are summarized within each of the technology-specific sections of this report.

Table 2-1: Inventory/Technical Potential Task Reports

Task Number	Report Title
1.1.2	Inventory Report for Agricultural and Food Processing Facilities, draft 12/2002
1.1.3	Inventory Report for Potential Landfill Bioreactors, 10/2002
1.1.4	Inventory Report for Sewage Treatment Plants, 10/2002
1.1.5	PV Database, Siting Requirements & Mini-Grid Technical Potential Report, 1/2003

2.4 Financial Analysis

Analysis of the financial viability of renewable energy system deployment constitutes a critical step in the assessment of market potential corresponding to a given quantity of technical potential. This analysis consists of several steps. First, financial performance of specific project prototypes is estimated in terms of internal rates of return (IRR). Second, the minimum acceptable project financial performance is expressed in terms of a distribution of hurdle rates. Finally, the project financial performance estimates and investor financial performance requirements are combined in a calculation of acceptance rates representing the portion of technical potential meeting or exceeding the minimum requirements of prospective investors in these renewable energy systems.

Prototypical Project Financial Performance

The overall financial performance of an energy project can be summarized using any of a large number of possible metrics, including IRR, simple payback, or levelized cost of energy. For this analysis, the IRR was selected as the measure of project financial performance. The IRR is defined as the discount rate corresponding to a net present value of discounted cash flows equal to zero, and reflects the influence of numerous, varied financial parameters for which values must be assumed. In the context of this market potential assessment project, these financial parameters can be broadly classified into three groups; fixed parameters, variable parameters, and "scenario-based" parameters. These three broad groups of financial parameters are discussed below.

Fixed Parameters. Fixed financial parameters are those for which a single value was assumed regardless of the year of installation or scenario. In this study examples of fixed financial parameters include inflation rate and marginal tax rates.

Variable Parameters. Variable financial parameters are those for which values were assumed to vary depending on installation year. In this analysis, which covered installations occurring from 2003 through 2012, an example of a variable financial parameter is the Federal Stimulus Depreciation Deduction. This deduction, which was created by a provision in a federal economic incentive package, applies to property placed in service after September 10, 2001. The bonus is set to expire September 11, 2004.

Scenario-based Parameters. Estimates of economic and market potential of emerging renewable energy technologies are subject to considerable uncertainty. Under these circumstances presentation of results in terms of expected values and corresponding ranges may enable more meaningful interpretation of results. For this analysis, expected economic and market potential results are augmented with results for *low-potential* and *high-potential* scenarios. The bases of the three scenarios are summarized in Table 2-2.

Scenario-based financial parameters are those for which values were assumed to depend upon scenario (i.e., low, expected, or high potential). In this analysis an example of a scenario-based financial parameter is capital cost of equipment utilized in manure/food processing waste energy recovery facilities. For the *high-potential* scenario, capital costs were assumed to decrease more rapidly than in the *expected-potential* scenario.

Table 2-2: Description of Low-, Expected-, and High-Potential Scenarios

Scenario	Description
Low Potential	Estimated potential based on conservative estimates of the values of financial and market parameters that yield estimates on the lower side of possible outcomes.
Expected Potential	Estimated potential based on best guesses of the values of financial and market parameters.
High Potential	Estimated potential based on charitable estimates of the values of financial and market parameters that yield estimates on the higher side of possible outcomes.

The basis of important financial parameters used in the IRR calculations is summarized in Table 2-3. Specific parameter values employed in the analysis are discussed in the technology-specific sections of the report.

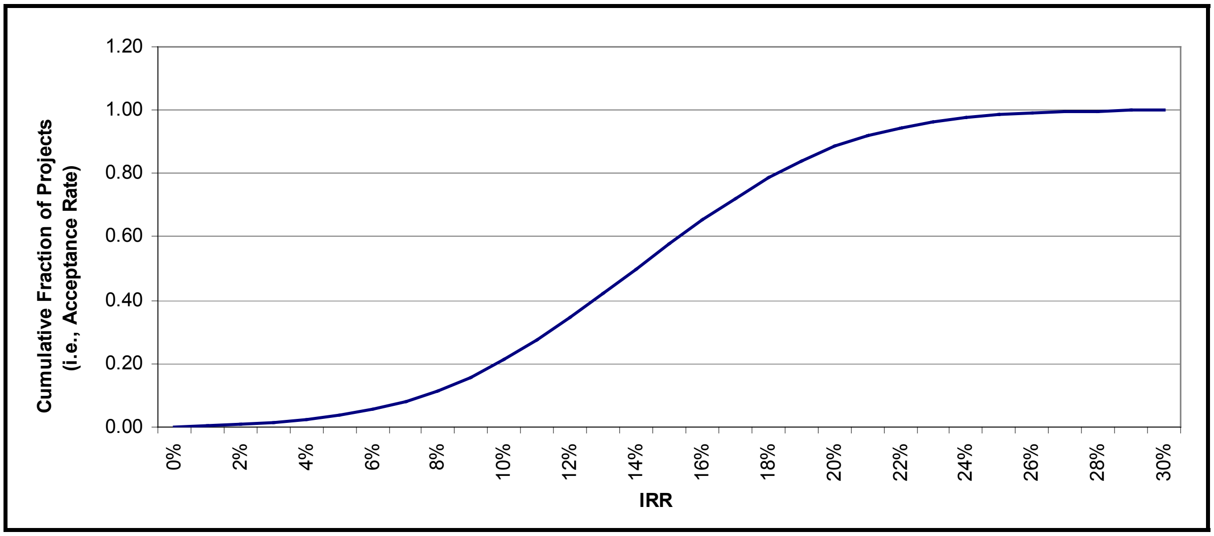
Table 2-3: Financial Parameter Type by Technology and Parameter

Cash Flow Financial Parameter	BI-PV	Biogas Ag./Food Digester	Biogas Wastewater Digester	Biogas Landfill Bioreactor
Inflation	Fixed	Fixed	Fixed	Fixed
Loan Interest Rate	Fixed	Fixed	Fixed	Fixed
Loan Term	Fixed	Fixed	Fixed	Fixed
Federal Tax Bracket	Fixed	Fixed	Fixed	Fixed
State Tax Bracket	Fixed	Fixed	Fixed	Fixed
State Depreciation	Variable	Variable	Variable	Variable
Federal Depreciation	Variable	Variable	Variable	Variable
Stimulus Depreciation	Variable	Variable	Variable	Variable
Capital Cost	Scenario	Scenario	Scenario	Scenario
O&M Cost	Fixed	Scenario	Scenario	Scenario
Rebates/Buydowns	Scenario	Scenario	Scenario	Scenario
Electricity Price	Scenario	Scenario	Scenario	Scenario
Capacity Factor	Variable	Scenario	Scenario	Scenario
Green Tag Value	Scenario	Fixed	Fixed	Fixed

Required Project Financial Performance

The conversion of technical potential into economic potential was accomplished using information from a previous study on required rates of return (i.e., hurdle rates) conducted by RER for the Commission.[1] The hurdle rate distributions developed in that study for site owners, developers, and lenders were adjusted to reflect current market conditions using the approach recommended in the study. That is, hurdle rate distributions were directly adjusted for the difference in the prime rate between the study period (1989) and the current year. The resulting hurdle rate distribution is illustrated in Figure 2-1.

Figure 2-1: Cumulative Hurdle Rate Distribution for Generation Projects



Each coordinate of the relationship depicts the fraction of decision-makers for which a specified rate of return satisfies their minimum IRR requirements. This fraction corresponds to the area under the cumulative hurdle rate distribution curve to the left of the specified IRR value. In the calculations of economic potential, these fractions are referred to as "acceptance rates". As shown, the mean required rate of return is just under 14% in nominal terms. As indicated in the RER study, this rate applies reasonably well to all three classes of decision-makers: site owners, lenders, and developers. As a result, it is used for all prototype analyses.

The issue has been raised concerning whether public and private entities have the same hurdle rate requirements. No documentation on this issue was found. What was learned from discussions with CH2M HILL is that from their experience public agencies such as those responsible for wastewater treatment don't make such project decisions in terms of hurdle rates. These agencies tend to look at what they are required to do by regulation, what

[1] Regional Economic Research, Inc., "Estimation of Hurdle Rates Applicable to Energy-Related Investments," June 25, 1989.

projects they would like to do to improve operations and manage risk, and their available budget. Based on these factors they tend to choose those projects that they feel are best suited for their agency and its ratepayers. They rarely look at projects on a comparative basis focusing on payback period.

For example, Inland Empire Utilities Agency (IEUA) headquarters is one of the few buildings to be platinum LEED (Leader in Energy and Environmental Design) certified in the United States. From a pure rate of return on capital investment perspective, this project would likely have a lower rate of return than most projects. Nevertheless it is a very good project because it demonstrates a lot of long term value that the Agency is trying to espouse for its ratepayers. Similarly, other projects that might be justified with a higher rate of return are not implemented because they don't achieve other benefits that the Agency values.

What does this mean in terms of expected actions by decision makers? In order to be consistent with decision-making hurdle rate criteria, a hurdle rate between 10 and 15% would be most appropriate to use. As a result, a 14% return requirement is used for all prototype analyses.

Calculation of Economic Potential

IRR results yielded by cash flow models represent financial performance for particular sets of conditions, or prototypes. Numerous project prototypes were defined to capture effects of variability in such factors as retail utility rates, equipment capital costs, and availability of tax and rebate program support initiatives. Whether or not a prospective project will be judged financially acceptable depends on the hurdle rate employed by a particular financial decision-maker. Individuals and organizations employ a wide range of investment decision hurdle rates, as described above. The calculation of economic potential for each prototype entailed two steps. First, the prototype IRR was used in combination with the hurdle rate distribution of Figure 2-1 to estimate an acceptance rate. Second, the economic potential was calculated as the product of the net technical potential corresponding to the prototype and the acceptance rate for the prototype.

2.5 Market Potential Model Overview

Results of the financial analysis were combined with technical potential results in calculations of the economic and market potential. The general form of the market potential model is illustrated in Table 2-4. Gross technical potential estimates are known from results of Program Planning and Analysis Project Tasks 1.1.2 through 1.1.5. Net technical potential at the start of year one is also assumed to be a known quantity. It is the gross technical potential less the quantity of renewable energy system capacity that is currently deployed. This latter quantity is simply the cumulative market potential at the beginning of year one.

Table 2-4: Illustration of Market Potential Model

Year	Gross Tech Potential Start of Year (Tg, kW)	Net Tech Potential Start of Year (Tn, kW)	Acceptance Rate (%)	Economic Potential During Year (E, kW)	Incremental Market Potential During Year (Mi, kW)	Cumulative Market Potential End of Year (Mc, kW)
1	Tg_1	Tn_1	A_1	E_1	Mi_1	Mc_1
2	Tg_2	Tn_2	A_2	E_2	Mi_2	Mc_2
3	Tg_3	Tn_3	A_3	E_3	Mi_3	Mc_3

The Commonwealth PIER Program will directly influence the quantity of nonresidential renewable energy system capacity deployed within the Chino Basin mini-grid. This identified capacity I_y contributes directly to incremental market potential. Additional market potential is calculated as the product of market penetration rate and remaining economic potential.

The market potential model elements are calculated as:

$$Tn_y = Tg_y - Mc_{y-1}$$
$$E_y = Tn_y \times A_y$$
$$Mi_y = I_y + \left(E_y - I_y\right) \times P_y$$
$$Mc_y = Mc_{y-1} \times \left(1 - D\right) + Mi_y$$

Tn_y = Net technical potential in year *y*

Tg_y = Gross technical potential in year *y*

E_y = Economic potential in year *y*

A_y = Acceptance Rate - Portion of net technical potential that is economic in year *y*

I_y = Identified projects in year *y*

P_y = Market penetration rate in year *y*

Mi_y = Incremental market potential in year *y*

Mc_y = Cumulative market potential in year *y*

D = Decay rate representing the portion of deployed capacity that is removed from operation each year

3

Building-Integrated Photovoltaic Market Potential

The assessment of nonresidential building-integrated solar photovoltaic (BI-PV) market potential within the Commonwealth mini-grid is described in this section. Technical potential results from Task 1.1.5 of the Planning and Analysis Project are augmented with financial and market information to estimate the quantity (MW) of nonresidential BI-PV that are projected to be installed in years 2003 through 2012.

3.1 Introduction

Estimates of technical potential of nonresidential BI-PV in the mini-grid area were presented in a previous report. The current project is an extension of that work that entails estimating economic and market potential corresponding to the estimated technical potential. As noted in the technical potential report, the ultimate focus of this project centers on estimating the impacts upon the electrical distribution system infrastructure. A consequence of this approach is that the analysis focuses on the applications and prototypes that will be responsible for the vast majority of the nonresidential BI-PV capacity likely to be installed during the 10-year study period. The analysis does not include a rigorous, comprehensive treatment of the many emerging BI-PV technologies involving additional displacement of conventional building materials. While these developments are an important area of work in the BI-PV arena, they are not the principal focus of this particular project.

3.2 Development of Prototypes

System prototypes for nonresidential BI-PV included rooftop, awning, parking lot shade structure, and other shade structure applications. With the exception of other shade structures, nonresidential BI-PV technical potential estimated previously under Task 1.1.5 of this Project was assumed to be correlated with building size and photovoltaic material type (i.e., crystalline versus amorphous). Here, calculation of economic potential is based on crystalline photovoltaic material only, and market potential is independent of photovoltaic material type. Implicit in this treatment is the assumption that BI-PV systems cover no more than half of available area at particular sites. For higher market penetration rates that may be realized in the more distant future beyond the period covered by this study, the distinction between crystalline and amorphous market potential would likely be more important.

Assumptions regarding system ownership represent a final distinguishing feature of project prototypes. Due to the availability of tax benefits for private sector investors in BI-PV, all BI-PV systems (including those situated on public facilities) were assumed to be privately owned. Implications of treatment of ownership in this manner are described below.

3.3 Estimates of Technical Potential

The technical potential for installation of nonresidential BI-PV in the mini-grid area was explored under a separate project task. A report summarizing the findings of that analysis was finalized in February 2003. In that report, technical potential estimates are expressed as the total photovoltaic system capacity that could be installed without regard to cost-effectiveness or other market constraints. Results were provided by major sector (public versus private), and geographically by zip code. These estimates represent the starting point for the market potential assessment covered by this task activity and report. Public and private sector BI-PV technical potential results are summarized in Table 3-1.

Table 3-1: Public and Private Sector Nonresidential BI-PV Technical Potential

Nonresidential Sector	Number of Facilities/ Establishments	BI-PV Technical Potential (kW)
Public Facilities	240	42,096
Private Establishments	3,857	483,943
Total	**4,097**	**526,039**

The basis of BI-PV Technical Potential results presented in Table 3-1 is alternating current (AC) power output (i.e., kW) at PTC conditions. PTC refers to PVUSA Test Conditions developed by the Photovoltaics for Utility Scale Applications (PVUSA) national public-private partnership to provide a system size rating basis reflective of conditions actually observed in the field. PTC weather comprises 1,000 W/m^2 plane-of-array irradiance, 20ºC ambient temperature, and wind speed equal to 1 m/s. In the remainder of this section BI-PV system sizes refer to AC power output at PTC conditions.

3.4 Analysis of Economic and Market Potential

The methodology employed in the analyses of economic and market potential was described in general terms previously in Section 2. In this section, the data sources and assumptions are presented specific to the analysis of nonresidential BI-PV economic and market potential.

Data Sources

Data from a variety of sources were incorporated into the analysis of nonresidential BI-PV economic and market potential. Principal data sources are described below.

Generation Profiles

Photovoltaic system power output varies quite considerably across hours, days, and seasons. This variability was assessed under a separate Planning and Analysis Project task. One result of this prior work was the development of an hourly generation profile for an assumed composite of photovoltaic system installation activity. In this market potential study this 8,760-hour composite photovoltaic generation profile was combined with electric utility tariff design information and rate forecasts to estimate the average value of electricity produced by BI-PV systems in the mini-grid area. The BI-PV composite was assumed to consist of the mix of PV system types and configurations summarized in Table 3-2.

Table 3-2: Characteristics of PV Composite Profile

Tilt (Degrees)	Azimuth	PV Material	Portion of BI-PV Mix (%)
0	N/A	Crystalline	60%
15	South	Crystalline	25%
90	South	Amorphous	5%
1-Axis Tracking	N/A	Crystalline	10%

Current SCE Tariffs

To determine the average value (i.e., cents/kWh) of electricity produced by BI-PV systems it is necessary to understand relationships between tariff designs and the shape of generation profiles. Tariffs applicable to nonresidential customers typically include seasonally variable energy and demand charges, which results in BI-PV energy value being sensitive not only to the quantity of energy (i.e., 1 kWh), but also to the time at which that electrical energy is produced. That is, 1 kWh generated during a summer afternoon is more valuable than 1 kWh generated during a winter morning. Electric tariffs published by SCE were combined with the generation profiles to estimate the average per kWh value of electricity produced by BI-PV systems. The following tariffs were used in the analysis:

- GS-1: Small Customers (<20 kW),
- GS-2: Medium Customers (20-500 kW), and
- TOU-8: Large Customers (>500 kW).

Future Rate Projections - CEC Electricity Outlook 2002-2012

The market potential study covers the period from 2003 through 2012. Whereas the tariffs described above provide information regarding the value of BI-PV-produced electrical energy today, to estimate the lifecycle cost-effectiveness of BI-PV it is necessary to predict the value of BI-PV-produced electrical energy during the entire span of BI-PV system useful life. Retail price forecasts from the Commission's Electricity Outlook Report were combined with the generation profiles and the SCE tariffs to estimate the value of BI-PV-produced electrical energy in future years.

eShapes Electrical Loadshapes

The value of electricity produced by BI-PV depends on the electric rate corresponding to the billing electric meter that is affected by the BI-PV system. The retail electric rate is largely governed by the maximum electrical demand of the customer. To estimate maximum electrical demand for particular establishments/facilities, building-type specific energy consumption information developed for the analysis of technical potential was combined with 8,760-hour electrical loadshape information from RER/Itron's *eShapes* library.

Current PV System Costs

The initial capital cost of installed BI-PV systems remains quite high. System cost data for medium and large PV systems from an active rebate program in California is summarized in Table 3-3. The typical cost is about 9 $/Watt (W). However, nearly one-quarter of the systems are either less than 6 $/W or more than 10 $/W. The distribution of per-unit system costs used in the economic and market potential analysis is summarized below.

Table 3-3: Current Available Nonresidential PV System Costs[1]

Cost Category	Per-Unit System Cost Range ($/Watt)	Number of Systems	% of Systems	Per-Unit System Cost Assumed ($/Watt)
Low	>2 & ≤6	21	6.9%	5.00
Typical	>6 & ≤10	232	76.6%	9.00
High	>10 & ≤14	50	16.5%	11.00
Total		**303**	**100.0%**	

Analytic Methodology

An overview of the general analytic approach used to calculate estimates of economic potential was included in Section 2. In this section some of the more detailed information pertaining only to BI-PV applications is presented. First, the key assumptions influencing

[1] Source: CPUC SGIP cost statistics for Level 1 PV systems PY2001 & PY 2002 active applications, 12/02.

estimates of project financial performance are described. Next, project financial performance results are combined with assumed hurdle rates in a calculation of economic potential. Finally, market penetration and decay rates are used to translate economic potential results into estimates of incremental and cumulative market potential within the mini-grid.

Project Financial Performance

BI-PV project financial performance, as measured by an Internal Rate of Return (IRR), was estimated for numerous prototypes. The cash flow modeling process involved assumption of values for a large number of financial parameters. Key sources of variability in IRR results included:

- SCE Retail Electric Rate (Small Commercial, Medium Commercial, and Industrial),
- INSTALLED PV System Price (Low, Medium, and High), and
- Installation Year (2003-2012).

A summary of assumptions used in the low-, expected-, and high-potential scenarios are presented in Table 3-4.

Table 3-4: BI-PV Potential - Scenario Financial Parameters

Parameter	Low	Expected	High
Buydown Rebate ($/Watt) **Nominal $ **Limit rebate to maximum of 50% of system cost	Year Rebate 2003 4.5 2004 4.5 2005 3.1 2006 2.7 2007 2.3 2008 1.9 2009 1.5 2010 1.1 2011 0.7 2012 0.3 SGIP sunsets at end of 2004 as planned, then CEC rebates are available according to the planned rebate schedule for small systems	Year Rebate 2003 4.5 2004 4.5 2005 3.6 2006 3.4 2007 3.2 2008 3.0 2009 2.8 2010 2.6 2011 2.4 2012 2.2 SGIP sunsets at end of 2004 as planned, then CEC rebates are available and every other incentive reduction is skipped.	Year Rebate 2003 4.5 2004 4.5 2005 4.0 2006 4.0 2007 3.2 2008 3.0 2009 2.8 2010 2.6 2011 2.4 2012 2.2 SGIP extended for 2 additional years at 4 $/Watt, then CEC rebates are available and every other incentive reduction is skipped.
Retail Electricity Price	CEC Forecast	CEC Forecast	Assume prices stop falling after 2007
Green Tags **5-year linear ramp up from $0.00/kWh to indicated level	0.005 $/kWh	0.02 $/kWh	0.04 $/kWh
Capital Cost **Linear ramp down. Prices indicated in this table are for a typical system.	2002: 9.00 $/W 2012: 5.00 $/W	2002: 9.00 $/W 2012: 4.00 $/W	2002: 9.00 $/W 2012: 3.00 $/W

BI-PV System Costs

Assumptions related to current BI-PV system costs were summarized above. To complete the economic potential analysis a *distribution of system costs* were estimated for each year during the period from 2003 to 2012. The distribution of prices that actually will be observed in these years will depend on numerous factors that are difficult to predict. However, BI-PV system prices [in real terms] are likely to drop with time as production volumes increase, progress is made down manufacturing, design and installation experience curves, transaction costs fall, and new production techniques and related equipment technologies are discovered and developed.

Price targets for installed systems developed by the National Renewable Energy Laboratory for its PV Roadmap served as the basis of assumptions regarding the magnitude of BI-PV cost reductions in the future. The PV Roadmap includes the following explanation of their price target[2]: "The system price paid by the end-user (including operating and maintenance costs) will be $3 to $4 per watt AC in 2010." Four dollars per Watt was assumed for the expected-potential scenario, while $3/W was the cost basis for the high-potential scenario. For the low-potential scenario a typical installed cost of $5/W was used in the analysis. These Roadmap price points are explained in part by the iterative process whereby increasing production leads to falling prices which leads to increasing demand which leads to further production increases.

These price targets were assumed to represent costs for typical projects and are analogous to the $9/W current cost presented in Table 3-3. Typical costs were assumed to decline linearly between 2002 and 2010, and then stay constant after 2010. System costs for low and high cost systems were assumed to decrease at a rate proportional to that estimated for typical systems. The resulting installed PV system cost distribution forecast is summarized in Table 3-5.

Table 3-5: Summary of Future PV System Costs (Real 2002 $)

Scenario	Year	7% of Systems Low Price ($/W)	77% of Systems Medium Price ($/W)	16% of Systems High Price ($/W)
	2002	5.00	9.00	11.00
Low Potential	2007	3.61	6.50	7.94
	2012	2.78	5.00	6.11
	2002	5.00	9.00	11.00
Expected Potential	2007	3.27	5.88	7.19
	2012	2.22	4.00	4.89
	2002	5.00	9.00	11.00
High Potential	2007	2.92	5.25	6.42
	2012	1.67	3.00	3.67

[2] http://www.nrel.gov/ncpv/vision.html

Value of On-site Generated Power

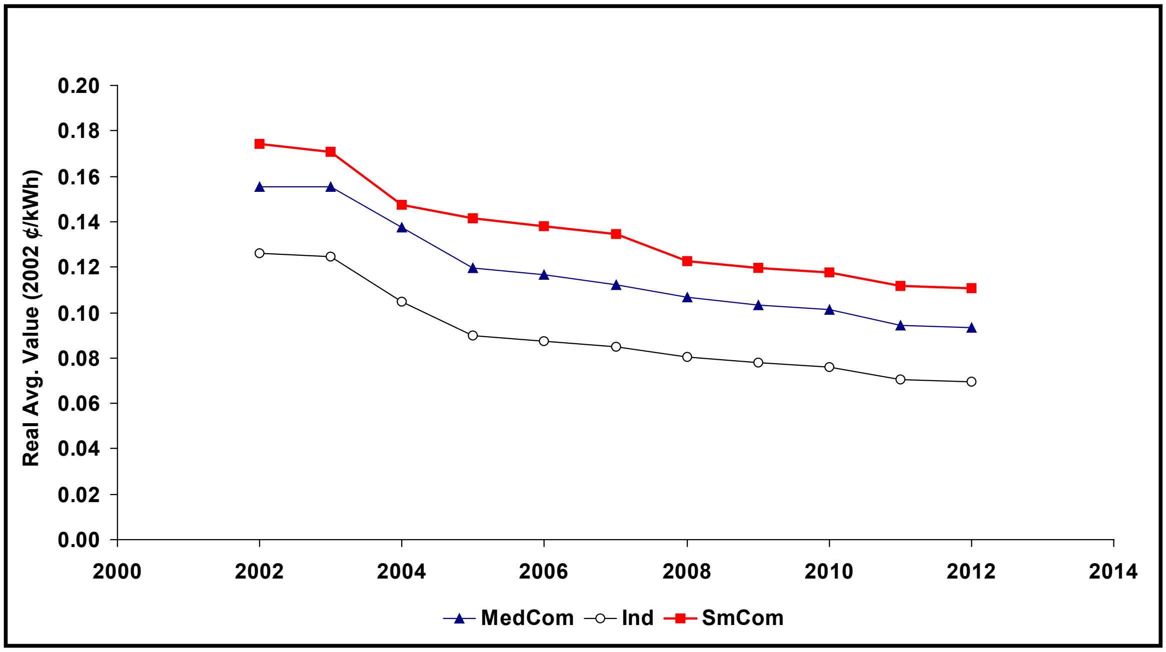
To monetize distributed generation (DG) system energy production estimates, information concerning the value of electricity produced by BI-PV systems must be incorporated into the analysis. BI-PV system electric power output exhibits both diurnal and seasonal variability. Because many electric rates of larger customers include time-sensitive elements, it is important that the average value ascribed to BI-PV system energy production reflects relationships between the utility rate schedule and the BI-PV generation profile. For this analysis SCE rate schedules were assumed based on customer type: GS-1 for small commercial, GS-2 for medium commercial, and TOU-8 for industrial. These rate schedules were combined with hourly values from the composite generation profile that serves as the basis of this assessment of Market Potential. The annual energy output corresponding to the composite generation profile is 1,972 kWh/year per 1.0 kW of AC-PTC photovoltaic system capacity. Results of this analysis for 2002 are summarized in Table 3-6.

Table 3-6: Average Current Value of PV Electric Energy (Real 2002 Cents/kWh)

Customer	Energy	Demand	Total
Commercial (Small)	17.4	0.0	17.4
Commercial (Med.)	13.5	2.0	15.5
Industrial	12.6	0.0	12.6

CEC retail price forecasts were used to estimate the average value of BI-PV electric production for other years. Average per-kWh values of PV generation for all other years are summarized graphically in Figure 3-1.

Figure 3-1: Forecasted Average Values of PV Electric Production



The CEC forecast extends through 2012. However, for the market potential assessment lifecycle cost-effectiveness of prospective BI-PV projects installed as late as 2012 must be estimated. To achieve this result retail value estimates must extend through to the end of the PV system's life. Assuming a 20-year life, this requires estimation of retail rates through 2032. A decelerating downward trend is observed in Figure 3-1. Given the uncertainty involved in predicting retail rates this far in the future, for purposes of this analysis retail rates for the period 2013-2032 were simply assumed equal to the 2012 results presented above.

Market Willingness to Pay for Non-Electric Attributes

Some portion of consumers ascribe value to the environmental and other distinctive attributes corresponding to PV-based electrical energy production, and are willing to pay for some quantity of these attributes. This willingness to provide economic contribution can be viewed in at least two different lights. First, a consumer may choose to install a PV system on his or her own building. For a consumer making this decision, if the total levelized cost of PV-based electrical energy production and power output exceeds the cost of electrical energy and power from conventional sources then the difference represents the incremental willingness to pay more for PV. Second, a consumer may choose to purchase the non-electric attributes corresponding to the production of a PV system owned by someone else. In this case the non-electric attributes may be represented by the value of the "green tags", or Renewable Energy Certificates (RECs).

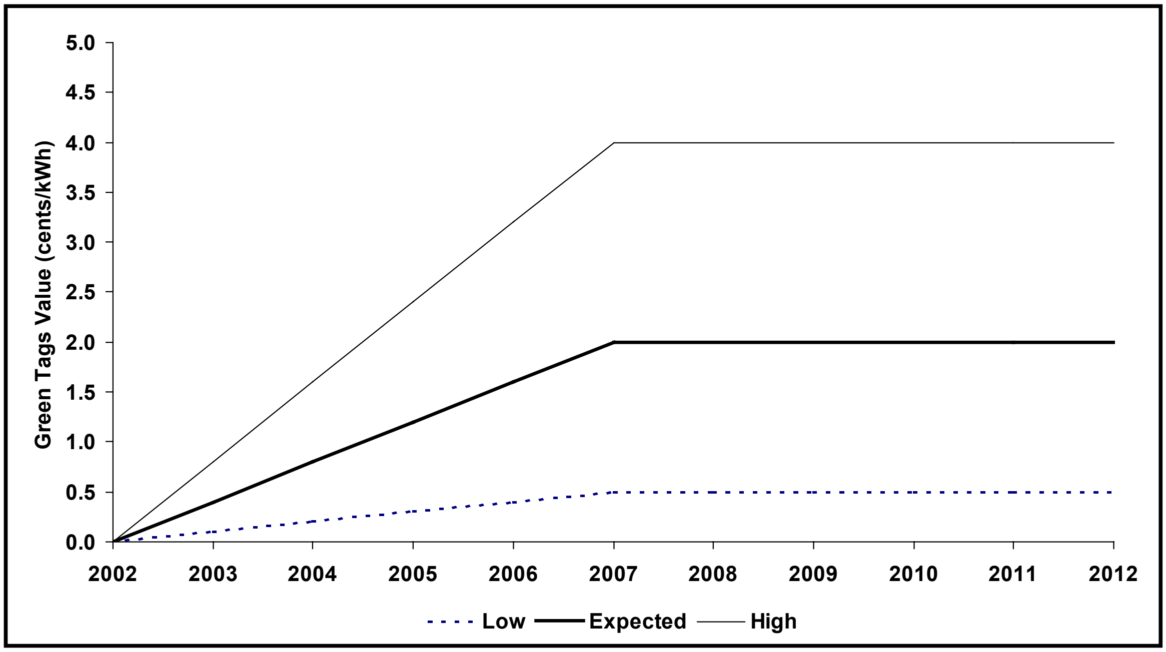
The total incremental value ascribed by society to non-electric attributes of PV-based electrical energy production and power output could be accounted for in the market potential assessment by using the "own building" model, the "green tags" model, or both. The "green tags" model was used for this analysis. Several characteristics leading to its selection are summarized below. Some buildings are physically unsuitable for PV, most renters are unable to install PV, and some consumers may want to buy small quantities of non-electric attributes. The green tags model is such that all of these consumers may be able to participate in the market for non-electric attributes even though they are unable to install PV on their own building. The green tags model also enables inter-sector transactions. For example, occupants of a high-rise residential property could be partially responsible for the installation of PV on the large, flat roof of a commercial property (e.g., a warehouse).

Although far from mature, markets for green tags do exist today. A consumer with a credit card and an Internet connection can purchase green tags in a matter of minutes. While markets for green tags exist, they are in their infancy. It may not yet be possible to purchase green tags corresponding solely to PV system operational attributes. To date, because of their market volume and relative cost of electric generation, most green tags transactions have involved wind power. However in the future, as RPS standards are implemented and generation volumes increase, markets for PV-based green tags are likely to develop.

It is not possible to know precisely what PV-based green tags prices will be in the future. In the case of one program involving 80 kW of PV, owners of some small PV systems in Oregon and Washington are selling the non-electric attributes corresponding to operation of their PV systems for 10 cents/kWh under 5-year contracts.[3] Conversations with others familiar with green tags markets and renewable energy project development suggest that larger-scale markets might price PV-based green tags somewhere in the neighborhood of 4 to 6 cents/kWh. For this market potential assessment a range of green tags values was defined. For the expected-potential scenario a value of 2 cents/kWh was assumed. Green tags values used in the analysis are summarized in Figure 3-2.

[3] Bonneville Environmental Foundation, press release: "The Bonneville Environmental Foundation Provides Economic Stimulus to Install New Solar," June 2002.

Figure 3-2: Green Tags Values Assumed for BI-PV (Real 2002 $)



Lastly, it is important to note that critical issues regarding ownership of green tags produced by net-metered photovoltaic systems remain to be resolved by the California Public Utilities Commission (CPUC). In Fall 2002, the CPUC issued Decision 02-10-062 that appears to suggest that such green tags would be owned by the electric utility providing the net-metering service. Representatives of the solar electric industry filed formal comments detailing their opposition to the decision.[4] This issue is expected to be considered again by the CPUC in the Summer of 2003.

<u>Tax Issues: Depreciation and Credits</u>

All projects were assumed eligible for the permanent Federal 10% tax credit for solar electric systems. This treatment is a consequence of the assumption of third-party ownership of BI-PV systems located on public facilities. Projects installed from 2003 through 2006 were assumed eligible for the State tax credit on solar electric systems. Five-year accelerated depreciation was assumed for Federal tax purposes, while 12-year straight depreciation was assumed for State tax purposes. Finally, BI-PV projects installed from 2003 through 2004 were assumed eligible for the 30% Federal Stimulus depreciation tax advantage option. The analysis was simplified by using 100% of the basis for depreciation calculations instead of 105%.

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[4] Comments by the California Solar Energy Industries Association on Implementation of the Renewable Portfolio Standard Program, January 6, 2003. Re: CPUC R.01-10-024, October 25, 2001, Order Instituting Rulemaking to Establish Policies and Cost Recovery Mechanisms For Generation Procurement and Renewable Resource Development.

Salvage Value

The analysis was simplified by excluding consideration of salvage value because several factors minimize its importance in this particular analysis. First, the system lifetimes are long (i.e., 20 years); discounting over this long timeframe tends to minimize the influence of salvage value on results of economic analyses. Second, the salvage value of PV modules will depend on the price of modules 20 years from now. Because the price of PV modules is expected to fall significantly during the next 20 years, the salvage value of modules installed today will be lower than what it would be if the price of modules remained constant in real terms. Third, the inverters remain the weak link in PV system reliability. Much of the annual maintenance costs are expected to be used for inverter maintenance. After 20 years the replacement inverters [assuming the original inverters do not last 20 years] may well be coming to the end of their useful life.

HVAC Effects

The analysis was simplified by excluding consideration of the incremental heating and cooling energy benefits attributable to certain BI-PV system types because these effects are expected to be relatively small in comparison to other factors influencing the results of primary interest (i.e., T&D investment deferrals). Were these benefits to be incorporated into an analysis such as this they would have to be consistent with the system configuration assumptions. For example, for this study a small portion of the BI-PV was assumed to be amorphous material oriented vertically. This BI-PV material is assumed to replace architectural glass, and no significant difference in thermal or optical properties is assumed.

Parking Revenue

The analysis was simplified by excluding consideration of the incremental non-electric benefit yielded by shading otherwise unshaded parking spots. The same PV system costs were used for each of the several types of PV systems, and electric bill savings yielded directly by PV system output were included in cash flow analyses. The analysis of PV market potential in parking spot shading applications excluded explicit consideration of two factors: 1) mounting support structures for this type of system can add $1 to $2 per Watt to system cost, and 2) shaded parking spots may generate more income than unshaded parking spots. For this analysis these two factors were assumed to offset each other.

IRR Solution

A spreadsheet-based cash flow model was used to iteratively solve for the internal rate of return for the many prototypes. The IRR solution was a two-step process. First, the maximum allowable loan size was calculated such that net savings in later years of the project remained positive. Second, the discount rate that yielded a net present value of discounted cash flows equal to zero was solved for iteratively.

Calculation of Economic Potential

IRR results from the cash flow modeling represent financial performance for particular types of projects. A large number of project prototypes were modeled to capture effects of variability in such factors as: retail utility rates for different sectors, PV system cost variability, and availability of tax and rebate program support initiatives. The general method used to translate estimates of technical potential, project financial performance results, and hurdle rates into estimates of economic potential was described in Section 2.

In the assessment of BI-PV potential, one additional element was added to treat the case of private sector ownership of BI-PV systems located on public sector facilities. Whereas for private sector "own building" applications the hurdle rate distribution was assumed continuous down even to very low hurdle rates (e.g., 2%), in cases of public sector "other building" applications the hurdle rate distribution was cut off at 5%. In no case was a public sector project deemed financially attractive if its IRR did not exceed 5%.

Calculation of Market Potential

The method used to translate estimates of economic potential into incremental market potential was summarized in Section 2. In each year, the incremental market potential is calculated as the product of economic potential and a market penetration rate (P_y). Estimation of market penetration rates (MPR) is the area of the overall analysis of solar-electric market potential subject to the greatest degree of uncertainty. While market penetration rates for previous years can be inferred based on economic potential estimates and observed installation activity, assumption of MPR values for future years requires making assumptions concerning the rate at which MPR will increase in response to factors such as public and private sector promotion, education, and technology familiarization activities. For this assessment of Market Potential, an estimate of the actual 2002 MPR was calculated. For subsequent years assumed rates of increase were applied to the 2002 MPR result."

First, calculated economic potential and actual nonresidential BI-PV installation data were combined to calculate an estimate of an actual market penetration rate for 2002 for the mini-grid. The result, 0.07%, was compared against results yielded by a similar calculation at the statewide level. The mini-grid and statewide results were similar. This MPR value was used as the starting point for this analysis. MPR values for subsequent years were estimated as:

- MPR Double from 2002 to 2003
  Justification: Assume the SELFGEN program would increase MPR
- MPR Triple from 2003 to 2004

Justification: Assume the SELFGEN program would have maximum effect in its fourth year

- MPR Double from 2004 to 2005
  Justification: Assume that MPR growth would continue, but at a slower pace, as SELFGEN support is reduced and more suppliers pursue fewer cost-effective projects (i.e., the total number of projects could decrease even as the MPR increased)
- MPR Remains constant during 2005 to 2012
  Justification: Assume that MPR would reach a steady-state value

Market penetration rate values assumed for the BI-PV analysis are presented in Table 3-7.

Table 3-7: Market Penetration Rates Assumed for BI-PV

Year	Rate
2003	0.15%
2004	0.45%
2005	0.90%
2006	0.90%
2007	0.90%
2008	0.90%
2009	0.90%
2010	0.90%
2011	0.90%
2012	0.90%

The calculation of market potential also includes a decay rate and effects of identified projects. For the BI-PV market potential analysis a decay rate equal to 5% was assumed. The 5% decay rate is included to account for the fact that as time passes, total power output of existing systems will likely decrease. Factors accounting for a non-zero decay rate include partial or complete system failures due to unaddressed equipment problems, performance problems due to other factors (e.g., failure to address shading issues due to foliage, failure to clean modules periodically), system removals due to building remodels/removals, and power output degradation due to physical properties of photovoltaic materials and modules.

While there are theoretical grounds for assuming a positive, non-zero decay rate, lack of relevant long-term data precludes development of a decay rate magnitude based directly on historical data. The 5% magnitude included in the analysis is an assumed value based on engineering judgment. At this time there is a great deal of uncertainty surrounding specification of the magnitude of a decay rate for photovoltaic systems. In the future, actual metered data may prove the 5% value included in this analysis to be high. However, given the level of uncertainty involved in estimating this value, and given the magnitude of the effect of this assumption on the overall Market Potential analysis, 5% is a reasonable value to use for purposes of this analysis.

Identified Projects represent BI-PV capacity currently anticipated to be completed due to the PIER/Commonwealth mini-grid program (under Projects 3.2 and 3.3). Assumed BI-PV public sector Identified Projects values are summarized in Table 3-8 for each scenario. For each of the three scenarios, BI-PV system capacity corresponding to the Identified Projects is assumed to be installed in three equal increments during years 2003 through 2005. Considerations governing specification of the decay rate for identified projects are identical to those for unidentified projects.

Table 3-8: BI-PV Identified Projects

Low Potential	Expected Potential	High Potential
235 kW	1 MW	3 MW

Economic and Market Potential Results

Economic and market potential results are summarized in Table 3-9 through Table 3-11. Results for the *expected-potential scenario* are presented in Table 3-9. This scenario corresponds to the most likely values of all financial and market parameters. In the expected-potential scenario the cumulative market potential achieved by the end of 2012 is estimated equal to approximately 20 MW.

Table 3-9: Expected BI-PV Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	546,975	546,904	189,503	617	685
2004	568,366	567,681	135,685	942	1,593
2005	588,815	587,222	66,462	928	2,442
2006	603,756	601,314	62,747	565	2,885
2007	615,349	612,464	113,797	1,024	3,765
2008	627,416	623,652	269,701	2,427	6,004
2009	638,773	632,769	379,394	3,415	9,118
2010	650,886	641,768	552,148	4,969	13,631
2011	661,521	647,889	431,235	3,881	16,831
2012	671,962	655,131	385,570	3,470	19,460

The incremental and cumulative expected market potential results for BI-PV in Table 3-9 are graphically illustrated in Figure 3-3.

Figure 3-3: Expected Scenario - BI-PV Market Potential

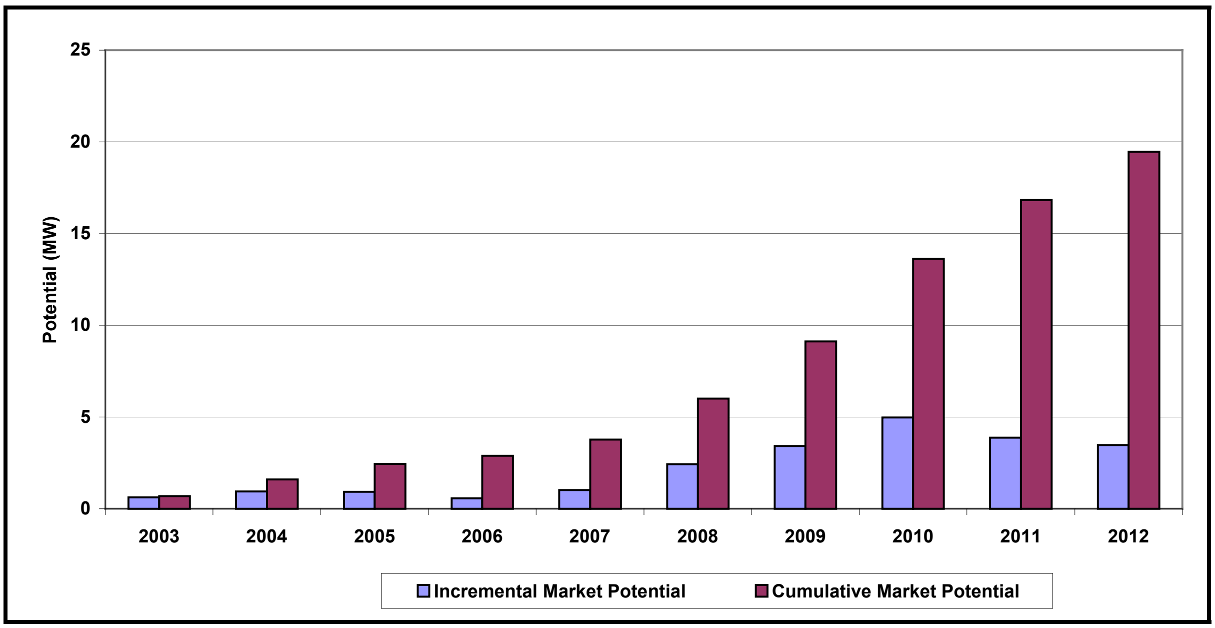
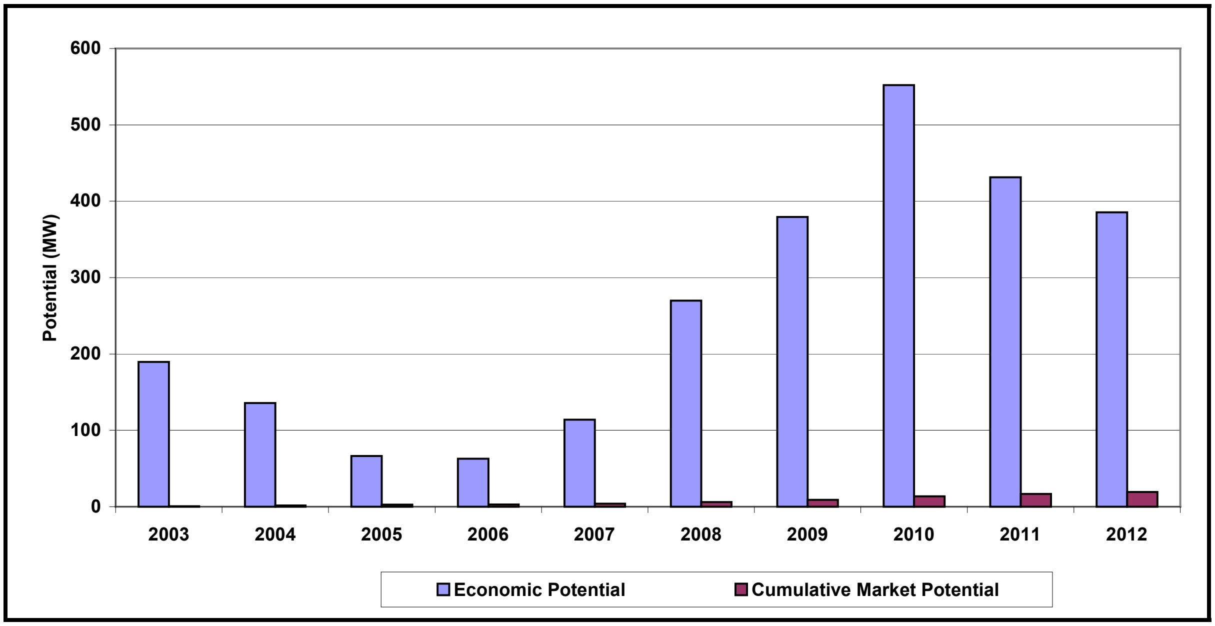


Figure 3-4 illustrates the economic potential versus the cumulative market potential for nonresidential BI-PV within the mini-grid area for the expected case scenario.

Figure 3-4: BI-PV Expected Scenario - Economic Potential versus Cumulative Market Potential



In Figure 3-4 the shape exhibited by Economic Potential data is explained in part by the assumption that PV system prices will fall until 2010 and then remain unchanged (in real terms) in 2011 and 2012 while rebate magnitudes will continue to fall in 2011 and 2012. The PV system price for 2010 came from an industry 'Roadmap'. Given the uncertainty surrounding projections this far in the future, the equipment cost was assumed to remain at the 2010 Roadmap value for the final two years of the study period. More generally, factors tending to offset falling PV system prices include: 1) the forecast of decreasing retail electric rates between 2003 and 2012, 2) assumption of falling rebate/incentive levels, and 3) assumption that the state tax credit expires at the end of 2006 and the federal tax code's bonus depreciation provisions expire at the end of 2004.

Economic and market potential results for the low-potential scenario are presented in Table 3-10. This scenario reflects the following conservative assumptions: higher capital costs, lower green tags values, smaller rebates in later years, and fewer projects installed as a direct result of the PIER/Commonwealth program. The cumulative market potential value reached by the end of the study period is estimated equal to 2,103 kW, which is approximately 11% of the level estimated for the expected-potential scenario.

Table 3-10: Low BI-PV Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	546,975	546,937	95,221	221	258
2004	568,366	568,109	58,236	340	585
2005	588,815	588,230	30,274	350	906
2006	603,756	602,850	29,298	264	1,124
2007	615,349	614,225	33,366	300	1,368
2008	627,416	626,048	35,441	319	1,619
2009	638,773	637,154	32,418	292	1,830
2010	650,886	649,057	29,549	266	2,004
2011	661,521	659,517	25,643	231	2,135
2012	671,962	669,828	8,341	75	2,103

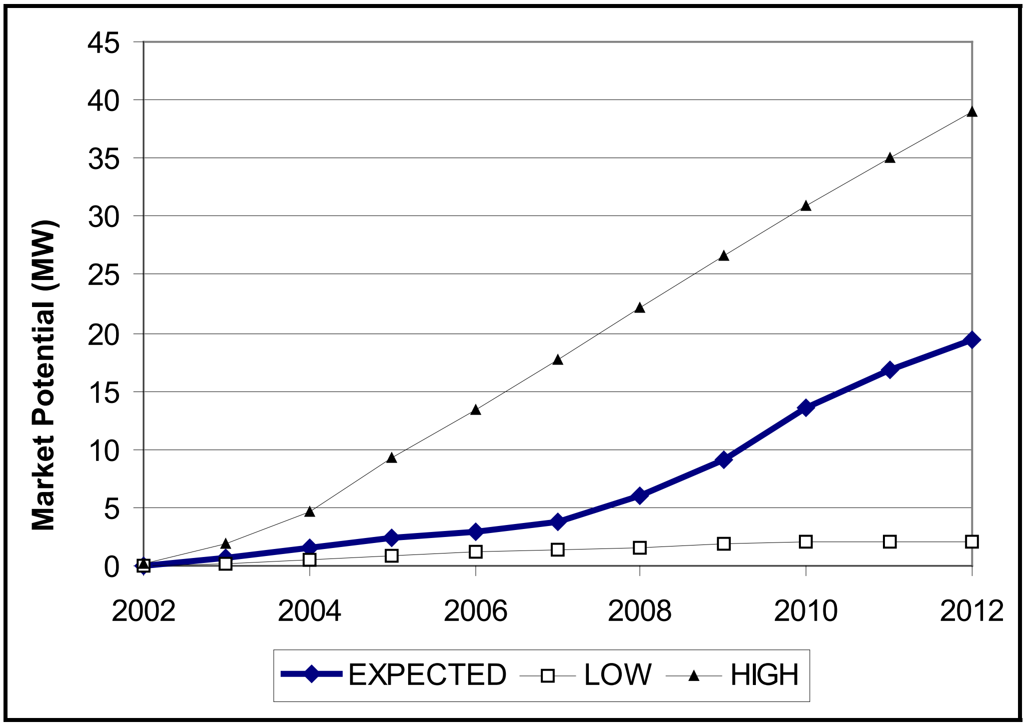
Economic and market potential results for the high-potential scenario are presented in Table 3-11. This scenario reflects a variety of charitable assumptions: accelerated reduction of capital costs, higher green tags values, larger rebates in later years, and additional BI-PV system capacity installed as a direct result of the PIER/Commonwealth program. The cumulative market potential value reached by the end of the study period is estimated equal to 39,005 kW, which is approximately twice the level estimated for the expected-potential scenario.

Table 3-11: High BI-PV Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	546,975	546,804	459,367	1,688	1,851
2004	568,366	566,516	426,211	2,913	4,671
2005	588,815	584,144	429,341	4,855	9,293
2006	603,756	594,463	503,293	4,530	13,358
2007	615,349	601,991	553,782	4,984	17,674
2008	627,416	609,742	596,950	5,373	22,163
2009	638,773	616,610	616,610	5,549	26,604
2010	650,886	624,282	624,282	5,619	30,893
2011	661,521	630,628	630,628	5,676	35,024
2012	671,962	636,939	636,939	5,732	39,005

Market potential results for the low-, expected, and high-potential scenarios are depicted graphically in Figure 3-5.

Figure 3-5: Cumulative BI-PV Market Potential by Year and Scenario



4

Dairy and Food Processing Waste Market Potential

4.1 Introduction

The Chino basin has a high concentration of dairy farms and a significant number of food processing plants within its boundaries. The organic waste of these facilities offers a significant potential for biogas production and electric energy generation. This section will discuss the process that was undertaken to quantify the market potential for this renewable energy resource within the Chino Basin mini-grid area. As is typical with the other renewable resource assessments, the market potential in this study has been evaluated under three scenarios: 1) expected case, 2) low development, and 3) high development.

4.2 Key Issues

There are two primary issues associated with these sources of biogas generation. The first issue is environmental regulation(s) and enforcement by air and water management agencies concerning dairy waste. This is the major driver for the success of dairy waste to energy projects in the State of California and in the Commonwealth mini-grid area. Ground water clean-up, in particular, is a major issue for the Chino Basin dairy industry. The secondary environmental concerns are reduction of ammonia and reactive organic gases (methane and nitrous oxide) released into the atmosphere and other related criteria and noncriteria air emissions. Should regulations be further stiffened and/or penalties enforced upon the dairies in the near future, there will likely be a significant increase in the amount of dairy waste needing to be disposed in the basin. Some of the current waste management practices would need to be changed, which could make more suitable waste material available for biogas generation.

The second major waste related resource issue is that there are other disposal and use options for the wastes in the food processing industry. These options directly compete with biogas to energy potential. If food processing waste-based biogas to energy is to be a viable option in the future, the associated technologies will need to be both well developed and viewed by the food processing industry as a cost competitive solution for waste management and/or disposal.

4.3 Development of Prototypes

The potential prototypes for these two biogas resources fall into several categories. For dairy waste to energy, the prototypes can be on-farm digesters or centralized facilities. The dairy waste in the Chino basin mini-grid area is comprised of three typical forms: wash water, feed lane and corral dried. Due to the ability to readily collect the waste and its high moisture content, the wash water and feed lane dairy waste are the prime candidate for anaerobic digestion; whereas the corral dried waste is more likely to feed a gasification or similar pyrolysis process. There are 167 dairies within the mini-grid. The economic and market potential reported in this section represent dairy wastewater and feed lane wastes combined. For food processing waste to energy, the only plausible prototypes are a relatively large scale on-site digester or a centralized facility where food wastes are incorporated with other organic wastes, (i.e., sewage waste, animal waste, etc.). Details on the sources and quantities of these waste streams can be found in the Inventory Report for Agricultural and Food Processing Facilities produced under a separate Planning and Analysis Project task.

An anaerobic digester (AD) biogas to energy plant can be a small on-farm facility run by a single farmer - using only the animal waste produced on the farm and using all the resulting electricity, waste heat and other by-products on the farm. Alternatively, the digestion of dairy waste can be implemented on a larger scale in a centralized anaerobic digester (CAD), taking feedstock from local farmers and food processors and subsequently marketing the resulting by-products. For a number of reasons, on-farm prototypes are not examined in this market potential assessment. On-farm AD configurations are less likely in this region due to: 1) Dairy AD scaling effects on economics, 2) the high concentration of dairies in the region, 3) the impact of rapidly encroaching residential and commercial development in the area, and 4) Dairy farmers typically do not want to own, operate, and maintain digesters and power generation facilities. The level of uncertainty regarding how many dairy farms and animal units will be in operation in the future is another major barrier to the development of on-farm AD facilities. For these reasons, Centralized AD facilities presents an attractive alternative within the Chino basin mini-grid area.

Due to technology maturity and cost issues, gasification of the corral dried waste stream will not be examined in this market potential study. Gasification is an endothermic process, which means it requires a significant amount of heat energy input to produce the biogas. Most research on gasification of manure has centered on the use of poultry and hog waste. Little is known about the use of cow manure as a feedstock for gasification. Even though gasifier ash has the potential to be a concentrated nutrient source and a component of fertilizer, the process is very costly and is not likely to be economically feasible within our 10 year market assessment horizon. This current situation could, however, change in the future. If environmental regulations and enforcement change with respect to the management of corral dried manure, the interest in this technology option could increase.

Two basic prototypes will be assessed for these two biogas resources within the mini-grid. The first is a Central AD facility that receives wash water and feed lane dairy waste from a number of farms. There, the waste is pre-processed to establish proper characteristics and placed into large digesters. The resulting biogas produced is then used as fuel to generate electricity. The most common prime mover is the internal combustion engine driven electric generator. A possible alternative in some areas would be the use of a small gas turbine or a microturbine (MT) as the prime mover. The basic process is the same regardless of the scale, but the capital costs, operation and maintenance of the digester and the sale of by-products is more cost-effective for a CAD than for an on-farm AD.

The second prototype is a centralized co-digestion (CCD) facility that mixes animal manure and food processing waste. This mixing of waste streams is believed to not only enhance digestion process efficiency but also provide an alternative waste utilization for the local food processing industry in the Chino Basin. There are 14 food processing facilities located inside the mini-grid as reported in the Task 1.1.2 inventory report. This is consistent with the "initial mini-grid" area as defined in the Task 1.1.1 report. Of these 14, there appear to be six food processors within the final refined mini-grid area. The market potential could be estimated for just these facilities, but if the market potential for food processing waste were realized, feedstock for CCD facilities would very likely include the wastes from these nearby resources. There do not appear to be any market barriers preventing this local area transfer. Making these additional resources available to the mini-grid market assessment only benefits the electric system within the mini-grid by allowing more biogas resource to generate electricity.

There has not been a significant amount of documented research that is publicly available performed to date in the area of co-digestion of animal waste and food processing waste. A few examples of food processing waste being co-digested with other farm animal waste were found, but no examples of co-digestion were found that incorporated dairy feed to waste. For this reason, this particular CCD prototype is based on much hypothesis and little known demonstrated technology implementation. The CCD is assumed to be basically the same as the CAD. The only difference is in the feedstock. The primary and limiting feedstock is assumed to be the food processing waste. The manure is collected from the feeding and milking areas of dairies. The co-mingling of these wastes provides more digestible material to the feedstock and thus increases the potential for gas production. The manure in this instance is also a feedstock to the diary waste centralized digesters. This overlap should not be a problem because the entire manure resource is not likely to be utilized by any single biogas production process under actual market conditions.

In both prototypes above, there is also an expected stream of cash flow benefits from the sale of residual digested materials (i.e., compost and liquid fertilizer) that is usually made available with additional refinements from this process. The combined value was assumed to be $50 per ton of compost produced.

One document that provides a number of case studies is the "Methane Recovery from Animal Manures – The Current Opportunities Casebook" produced by Resource Development Associates for the National Renewable Energy Laboratory, September 1998. Twenty three case studies are presented, of which one is of a centralized AD facility. It is this CAD facility on which the prototypes are based for this study. The facility was constructed in 1998 in Southern California, outside of the Commonwealth Chino basin mini-grid. The facility is designed to receive dairy manure from 10,000 dairy cows. In this case, there were approximately 85 dairies within a 30 mile radius of the facility. Third party contractors collect the manure daily with approximately 10 trucks operating for 10 hours each day, Monday through Saturday. The digester is made up of 10 tanks capable of holding 530,000 gallons of slurry in total. The digester is a complete-mix system configured as a two-stage mixed thermophilic reactor. The slurry-based system was designed to produce approximately 300,000 cubic feet of biogas per day with a methane content of approximately 60%. The capital cost was $5.5 million in 1998 dollars. The prime mover is an internal combustion engine with a rated capacity of 1050 kW. The centralized facility sells electricity back to the grid. Annual operating and maintenance costs were not reported. The digested slurry is dewatered and the byproducts used as liquid organic fertilizer and the solids are either composted or further refined into dry fertilizer.

Note that all dairy and food processing biogas generation prototypes are sized below 1,000 kW so that they may qualify for net metering/standby charge exemption and the California Self Generation Incentive Program Level 3-R rebates currently set at the lower of $1.50/watt or 40% of eligible system cost. No literature on economies of scale for CAD or CCD facilities was found. Given this lack of information, no attempt was made to estimate an optimum size for a centralized AD digester. The benefits of self-generation incentives and net metering for projects less than 1 MW were considered to outweigh the potential for reduced unit costs of building larger centralized AD facilities.

The cost of transporting the waste is assumed to be offset by the carting fees charged by the operator of the digester facility as a simplifying assumption in the analysis for both prototypes. The cost information found on this was in the $4-$7 per ton range. This assumption may not hold in the future, should environmental regulations for waste disposal become more stringent.

The key characteristics for determining the economic and market potential of these two prototypes are discussed in greater detail later in this section.

4.4 Estimates of Technical Potential

The technical potential for installation of agricultural and food processing waste biogas to energy facilities in the mini-grid was explored under a separate Planning and Analysis Project task. A report developed by CH2M HILL summarizing the findings of that analysis was completed in April 2003. In that report, technical potential estimates are expressed as the total biogas to energy system capacity that could be installed without regard to cost-effectiveness or other market constraints. Results were presented by dairy and food processing waste category. These estimates provide the starting point for this market potential assessment.

Even though the Dairy Waste Inventory Report quantified the number of dairy animal units within an area that does not exactly overlay the Commonwealth mini-grid boundary, these dairies are located within a reasonable distance of a centralized digester. Therefore the gross technical potential estimate produced in the inventory report is appropriate for use in this mini-grid market assessment. These cumulative annual estimates are shown in Table 4-1.

Table 4-1: Dairy and Food Processing Waste Biogas Technical Potential

Year	Dairy Biogas Technical Potential (kW)	Food Processing Biogas Technical Potential (kW)
2003	6,300	37,000
2004	5,950	37,000
2005	5,556	37,000
2006	5,163	37,000
2007	4,769	37,000
2008	4,375	37,000
2009	3,981	37,000
2010	3,588	37,000
2011	3,194	37,000
2012	3,150	37,000

Note that the cumulative dairy waste technical potential decreases by over 50 percent during this period, due to expected further reductions in active agricultural acreage and continued conversion of farmland being rezoned to residential and commercial uses.

4.5 Analysis of Economic and Market Potential

For this analysis, economic potential will first be examined from the perspective of the most likely or expected set of conditions for developers of these prototypical technologies. A *low potential* scenario and a *high potential* scenario will then follow. The characteristic parameters that can separate the low, expected, and high scenarios include installed capital cost changes over time, electric retail and wholesale prices, state and federal tax credits, and other state and federal incentives, such as performance-based incentive payments and capital cost buy down payments.

Data Sources

A number of sources for necessary data were collected for this analysis. The data includes retail and wholesale electric and gas rates. The retail tariffs are those of Southern California Edison (SCE). The electric price forecasts are derived from the CEC's Electricity Outlook 2002-2012 report. The current price for natural gas was based upon Southern California Gas's commercial tariffs.

To gain an understanding of the system costs associated with anaerobic digestion technology and the associated electric generation costs, a number of sources were examined. The primary sources on AD technology costs include the EPA's AgSTAR Program website, the "Dairy Waste Anaerobic Digestion Handbook," the "Agricultural Biogas Casebook," the "Methane Recovery from Animal Manures -- The Current Opportunities Casebook," the "Anaerobic Digestion of Farm and Food Processing Residues" report, and conversations with the authors (CH2M HILL) of the earlier Task 1.1.2 report on agricultural and food processing biogas resources within the Commonwealth Chino basin mini-grid. Additional generation cost data was obtained from the "Technology Characterization: Reciprocating Engines" report prepared for the EPA.

Analytic Methodology

Each assessed prototype was developed using a range of expected system costs. The system cost components include: capital costs, construction costs, operating and maintenance costs, major component overhaul/replacement costs, etc. Cash flow analyses were subsequently performed over a ten year planning horizon. The cash flow analysis was used to compute the internal rate of return (IRR) for each prototype for each of the ten years of the analysis. The project measure of performance (IRR) was then used to determine the remaining technical potential that was economic. Finally, a market adoption model was employed to determine the market potential for each year of the assessment.

System Costs

Centralized dairy biogas AD Prototype costs were developed for low, expected or average case, and high cost scenarios. Each was developed to include a range of costs associated with the construction of a CAD. The cost for the electric generation aspects was fixed for all three scenarios at a single expected value of $2,000/kW in 2003 dollars. This generator cost component includes costs for reciprocating engine generator sets, electrical interconnection equipment, heat recovery equipment, installation labor and materials, project and construction management, engineering fees, contingency fees, and gas cleaning and emissions control equipment, which are necessary air pollution abatement costs within the Chino basin mini-grid region. Fixing the generation component costs as a constant value was selected for this analysis so that the effects of varying the CAD costs could be observed in the final results. Generation costs can certainly vary, but they are not expected to vary nearly as significantly as those of the digester facilities. Table 4-2 illustrates the various installed costs used in this economic assessment[1]. As shown the overall system costs are the same for each of the two prototypes. There is no evidence that any additional equipment is required for a centralized co-digestion facility, relative to the capital component requirements of a centralized dairy waste only AD facility.

Table 4-2: AD System Installed Capital Costs by Prototype

Prototype	Low Cost ($/kW)	Average Cost ($/kW)	High Cost ($/kW)
Centralized Dairy Biogas	5,150	7,950	10,750
Centralized Dairy & Food Waste Biogas	5,150	7,950	10,750

The components that make up the costs include IC engine generator set costs, digester costs, heat recovery costs, pretreatment (screening, sand and rock removal) costs. A wide range in the costs for individual components was observed while researching the available literature. All the costs were developed on a unitary ($ per kW) basis. The combined engine generator costs ranged from $750 to $1,500 per kW of gross nameplate capacity. IC engine costs were not developed separately from the electric generator/controls costs. The digester costs ranged from $4,000 to $7,000 per kW. The heat recovery costs ranged from $200 to $300 per kW. The emissions controls varied from $0 to $1,500 per kW. The pretreatment costs ranged from $200 to $250 per kW. These cost ranges were added to one another to compute a low and high system cost. The average system cost was computed as the average of the high and low.

The installed system costs in Table 4-2 are in 2003 dollars and are assumed to decline by 2% per year over the ten year planning horizon under the “expected case” economic potential scenario. This assumption was made because the technology is relatively young and it is expected that over time and given greater experience with this technology the capital and construction costs will decline on a real basis. O&M costs for this technology and biogas resource are also expected to decline over time for the same reason. O&M costs for both the digester and the generator combined starts at $0.0325/kWh in 2003 and declines at 1% per year over the 10 year planning horizon for the *expected case* economic potential scenario.

[1] Low, average, and high in this table should not be confused with the economic & market potential scenarios labeled “low”, “expected” and “high.”

<u>*Estimated Value of Generated Power*</u>

The forecast of retail and wholesale prices of electricity used in the economic potential analysis are summarized in Table 4-3, along with the estimated value of green tags for biogas projects. All values are expressed in 2003 dollars. For the high market potential scenario, the retail industrial electric rate is the same as in the low and expected scenarios for the first five years. After 2007, it is assumed to remain at its 2007 level for all remaining years. This reflects the possibility that retail electric rates may remain high should the supply of electricity become constrained due to the lack of generation, transmission constraints or both. The same is true for wholesale electric rates.

Table 4-3: Estimated Values of Generated Electricity

Year/Scenario	Retail Industrial Rate ($/kWh)		Wholesale Electirc Rate ($/kWh)		Green Tab Value ($/kWh)
	Low & Expected	High	Low & Expected	High	All
2003	0.117	0.117	0.032	0.034	0.005
2004	0.098	0.098	0.029	0.034	0.005
2005	0.084	0.084	0.027	0.034	0.005
2006	0.082	0.082	0.028	0.034	0.005
2007	0.080	0.080	0.030	0.034	0.005
2008	0.076	0.080	0.031	0.034	0.005
2009	0.073	0.080	0.033	0.034	0.005
2010	0.071	0.080	0.034	0.034	0.005
2011	0.066	0.080	0.036	0.034	0.005
2012	0.065	0.080	0.037	0.034	0.005
2013	0.065	0.080	0.037	0.034	0.005
2014	0.065	0.080	0.037	0.034	0.005
2015	0.065	0.080	0.037	0.034	0.005
2016	0.065	0.080	0.037	0.034	0.005
2017	0.065	0.080	0.037	0.034	0.005
2018	0.065	0.080	0.037	0.034	0.005
2019	0.065	0.080	0.037	0.034	0.005
2020	0.065	0.080	0.037	0.034	0.005

Some portion of all types of consumers ascribe value to the environmental and other distinctive attributes corresponding to biogas-based electrical energy production, and are willing to pay for some quantity of these attributes. A consumer may choose to purchase the non-electric attributes corresponding to the production of a biogas system in the form of green tags, or Renewable Energy Certificates. The *total incremental value* ascribed by society to non-electric attributes of biogas-based electrical energy production and power output can be accounted for in the market potential assessment by using green tags.

While markets for green tags exist, they are in their infancy. It may not yet be possible to purchase green tags corresponding solely to biogas system operational attributes. To date, because of their market volume and relative cost of electric generation, most green tags transactions have involved wind power. However in the future, as newly developed Renewable Portfolio Standards (or RPS) are implemented and generation volumes increase, markets for biogas-based green tags are likely to develop. It is not possible to know precisely what biogas-based green tags prices will be in the future. Conversations with others familiar with green tag markets and renewable energy project development suggest that larger-scale markets might price biogas-based green tags somewhere in the neighborhood of 0.5 cents/kWh. Since better information is not currently available, the biogas green tag value has been assumed to be fixed over time.

Valuation of Biogas Cogeneration System Recovered Thermal Energy

The thermal energy that is available for recovery from the combustion of biogas in either IC engines or micro turbines contributes favorably to the economics of a biogas cogeneration system. The recovered heat is used by the anaerobic digestion process to maintain the necessary temperature for the production of biogas, thereby avoiding the purchase of supplemental heat or the production of heat from other fuel sources. **For this analysis, the value of this thermal energy is not explicitly quantified**. The recovery of thermal energy has the effect of lowering the digester's annual operations and maintenance costs. As a simplifying assumption, the thermal energy is used to heat the digester and the benefit is not explicitly quantified. The natural gas does not need to be purchased as a heating fuel is the value of the thermal energy. This cost is thereby avoided and does not need to be accounted for in the calculations.

Regulatory Compliance Benefits

There are several environmentally related non-energy benefits associated with dairy waste biogas to energy facilities. The first major benefit is groundwater decontamination. This is very significant to the Chino basin mini-grid area due to the nitrates (salts) that leach into the groundwater as a result of current manure management practices. One method for groundwater contaminant removal that is actively being employed by IEUA in the mini-grid area is reverse osmosis. It is expected that as improvements in manure management are made to facilitate the collection and transportation of dairy waste to CAD facilities, fewer salts and related contaminates will be required to be removed from the groundwater, thereby reducing the future cost of groundwater cleanup efforts in the basin.

The second environmentally related non-energy benefit is the reduction in reactive organic and greenhouse gas emissions, namely ammonia, methane and nitrous oxides. It is conceivable that markets for methane emission reduction credits will be created by regulatory actions in the future. Emissions from ruminant animals are an important contributor to total emissions of gasses involved with the climate change issue. The Climate Trust is one example of an organization that may be able to facilitate the sale of greenhouse gas (GHG) reduction credits by owners of dairy digesters on the basis of methane emissions reductions. Niche markets may well exist for this within 10 years. The development of an ammonia credits market is much more uncertain. The drawbacks of ammonia emissions are more limited to odor problems and to a lesser degree the impact on local vegetation as a result of re-deposition. More importantly, ammonia is believed to be a precursor for PM_{10} and may in the near future be valued far greater than GHG credits. However, it is not clear that a market for ammonia credits is as likely to develop as for methane credits.

A key valuation aspect from the economic potential perspective is whether the benefits are accrued by the owner of the CAD facilities. In the case of groundwater contamination, owners of CAD facilities would not necessarily be expected to be responsible for ground water cleanup. For this market assessment one of the prototypes includes a public agency to own and operate CAD facilities. A public agency within the mini-grid (IEUA) has been contracted to initiate a pilot plant to test groundwater contamination cleanup in the mini-grid area -- that is also testing a dairy CAD pilot facility. In this case it is certainly conceivable that the public agency will realize future groundwater cleanup cost savings from their dairy CAD operations. The real question is: what is the estimated magnitude of this financial benefit?

To incorporate the impact of a future GHG credits market into the economic potential assessment, the issues of GHG quantification and credit valuation need to be addressed. Quantification is difficult in this instance because the quantity of methane emissions avoided is not equal to the quantity of methane produced by AD. It is directly a function of the amount of potential manure per cow that is collected. Under the prototypes developed for this analysis, only 20% of the total dairy waste is suitable for collection for AD purposes.

The valuation of the GHGs has been done on a carbon dioxide equivalent (CO_2E) basis. Methane is assumed to have a CO_2E of 21:1. In other words, every ton of methane is assumed to be equivalent to 21 tons of CO_2. In the case of nitrous oxide (N_2O), the assumed CO_2E conversion is 310:1. The value of the GHG credits was computed on an animal unit (AU) basis. The final value for methane used in this assessment was $1.06 per AU per year and the value of N_2O was $0.91 per AU per year for a total GHG credit of $1.97 per AU per year.

Based on analysis and discussions between CH2M HILL and IEUA, an avoided cost of salt contamination removal was developed based solely on the variable O&M costs for a reverse osmosis system. The avoided cost value derived was $688 per AU. The avoided cost impact of the CAD on ground water contamination was assumed to take five years from the time the

CAD began operation. The derivation of a value for this environmental benefit will further be addressed in the early process analysis and selection tasks of Project 3.1 dairy waste to energy pilot of the PIER Commonwealth Program.

Cash Flow Modeling

Both prototypes were run under three ownership and operation schemes. The first scheme was structured such that the facility was privately owned and the electricity was sold back to the grid at wholesale prices. For the second scheme, the facility was owned by a public agency (such as IEUA) and the electricity used entirely on-site. In the third scheme, the facility was owned by a public agency and the electricity sold back to the grid. These three schemes provide a distribution of probable ownership and operation scenarios. Each scheme is weighted in order that the results may be combined into a single weighted average scenario. The first through third schemes were weighted to represent 20%, 40% and 40% respectively, of the estimated technical potential.

Financing is fixed across all the scenarios. It has been assumed that the owners will finance 50% of the remaining capital costs. Loans are assumed to have an interest rate of 8% and a term of 20 years. No tax credits are assumed to exist under any of the economic potential scenarios. For the private ownership model, federal depreciation is taken over 10 years on a declining depreciation schedule, whereas the State depreciation schedule is based on 12 year straight-line.

Several variables in the economic potential assessment change across the three economic potential scenarios. This cash flow model is performed for each of the ten years in the planning horizon.

In the low potential scenario, the only financial condition that was changed was the existence of utility SGIP rebates. Currently these incentives are due to expire towards the end of 2004. All other factors including the price of electricity, capital costs, and O&M remain the same as in the expected potential scenario.

In the high potential scenario, several financial factors are adjusted for this scenario. The retail price of electricity is frozen in 2007 for all remaining years. This is shown in Table 4-3. Wholesale electric prices are kept at the 2003 level for all years. This assumes that the power market in California will tighten over time from that currently forecasted by the CEC.

Capital and O&M costs are assumed to drop a little more steeply than in the expected potential scenario. Capital costs drop by 2.5% per year and O&M costs drop by 2% per year through 2012.

Annual capacity factors for the CAD biogas generation facilities are assumed to increase more rapidly over time as well. They are assumed to average 80% in 2003 and rise to 90% by 2008.

The Cash Flow modeling process involves running each economic potential scenario for each prototype under the three capital cost structures for each of three ownership and operation schemes. The range of system costs is not assumed to be normally distributed. Instead, a skewed distribution is assumed, with 16% of the technical potential burdened by high costs, 77% subject to average costs and 7% enjoying low costs. The internal rate of return (IRR) is determined through iteration for each scenario for each year.

Calculation of Market Potential

Few examples of CCD technology using food processing waste exist at this point in time within the United States. It is assumed that through the PIER Program and other renewable energy programs that knowledge, experience, and equipment will be developed and market interest will grow. The adoption rate, or market potential fraction, for this technology has been assumed to be zero in 2003 and increase to 5% of economic potential by 2008. After 2008, the adoption rate is assumed to be a constant 5%. For dairy waste CAD, the market is more mature and it is estimated that a constant 40% of the remaining economic potential will be realized.

In all cases, the market adoption rate assumptions remain the same across the low, expected, and high market potential scenarios. There is no assumed market decay rate for this analysis due to the very limited number of facilities that could potentially be developed in the Chino basin mini-grid region.

Economic and Market Potential Analysis Results

The analysis results for each of the three established economic and market potential scenarios are presented below.

Expected Scenario

Table 4-4 shows the results from the expected case economic and market potential for the dairy waste biogas resource. The scenario presented in this table is the portion of technical potential that is expected to be economically viable and then subsequently built within the mini-grid over the 10-year planning horizon of this assessment.

The incremental known projects, shown in column 4 of Table 4-4 include those projects within the Commonwealth Program that are likely to be developed. They have the effect of reducing the remaining economic potential and increasing the cumulative market potential.

They were developed by the Commonwealth team using rough estimates of what was expected to be developed at the time of the market assessment.

Table 4-4: Expected Case Dairy Biogas Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	6,300	6,300	0	418	167	167
2004	5,950	5,783	150	145	58	375
2005	5,556	5,331	0	267	107	482
2006	5,163	4,830	0	282	113	595
2007	4,769	4,324	0	243	97	692
2008	4,375	3,833	0	208	83	775
2009	3,981	3,356	0	206	82	858
2010	3,588	2,880	0	163	65	923
2011	3,194	2,421	0	130	52	975
2012	3,150	2,325	0	154	62	1,036

Note: Current existing operational capacity is 250 kW within the Chino Basin Mini-Grid.

The results suggest that the remaining economic potential is less than 10% of the net technical potential in any given year. It is important to remember that there is a range of expected costs and the economics for any one entity that builds a dairy waste CAD can vary significantly. To illustrate this point,

Table 4-5 presents the measure of economic performance (IRR) for each of the three system costs (low, average, and high) used in developing economic potential for the first dairy prototype under a public ownership scheme where all generated electricity is used on-site. If actual capital costs can be kept low, this technology can be very cost effective. For example, an IRR of 20% translates into an economic potential fraction of 88% of the technical potential. For the prototype cost distribution depicted in

Table 4-5, the weighted average of the IRR analysis produced an economic potential fraction of 16.4% in the first year. This weighted average economic potential fraction for public agency-owned dairy CAD is calculated by multiplying 20.61% (IRR for low cost system) by a weight of 0.07, multiplying 7.75% (IRR for average cost system) by a weight of 0.77, and multiplying 0.29% (IRR for high cost system) by a weight of 0.16. The weights are estimates of the mix of the likely costs..

Table 4-5: Economic Performance Distribution for Public Agency-Owned Dairy CAD (IRR %)

Year	Low Cost Systems IRR (%)	Average Cost Systems IRR (%)	High Cost Systems IRR (%)	Weighted Average IRR (%)
2003	20.61%	7.75%	0.29%	16.40%
2004	19.41%	7.43%	0.31%	13.00%
2005	19.01%	7.44%	0.52%	13.00%
2006	19.19%	7.70%	0.87%	16.10%
2007	19.38%	7.97%	1.22%	16.10%
2008	19.58%	8.26%	1.59%	16.20%
2009	19.92%	8.62%	2.00%	19.70%
2010	19.92%	8.62%	2.42%	19.70%
2011	20.75%	9.42%	2.85%	19.90%
2012	21.49%	9.96%	3.35%	24.40%

Table 4-6 shows the results from the expected case economic and market potential analyses for the food processing waste biogas resource.

Table 4-6: Expected Case Food Waste Biogas Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	37,000	37,000	2,457	0	0
2004	37,000	37,000	1,968	20	20
2005	37,000	36,980	1,966	39	59
2006	37,000	36,941	2,388	72	131
2007	37,000	36,869	2,406	96	227
2008	37,000	36,773	2,450	123	349
2009	37,000	36,651	2,967	148	498
2010	37,000	36,502	2,983	149	647
2011	37,000	36,353	3,109	155	802
2012	37,000	36,198	3,890	194	997

The incremental and cumulative market potential results for dairy biogas in Table 4-4 are graphically illustrated in Figure 4-1.

Figure 4-1: Expected Case Dairy Biogas Market Potential

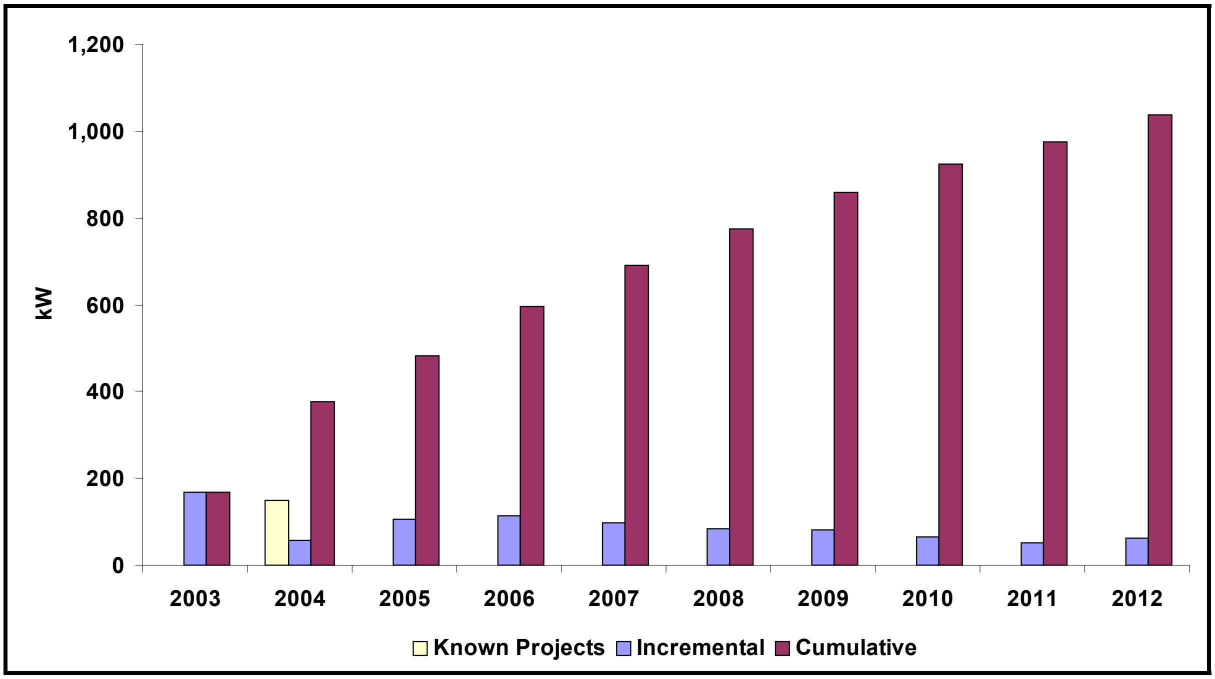


Figure 4-2 illustrates the economic potential versus the cumulative market potential for dairy biogas within the mini-grid area for the expected case scenario. By the end of the planning horizon, total market potential just exceeds 1,000 kW or 1 MW.

Figure 4-2: Dairy Economic Vs. Cumulative Market Potential – Expected Case

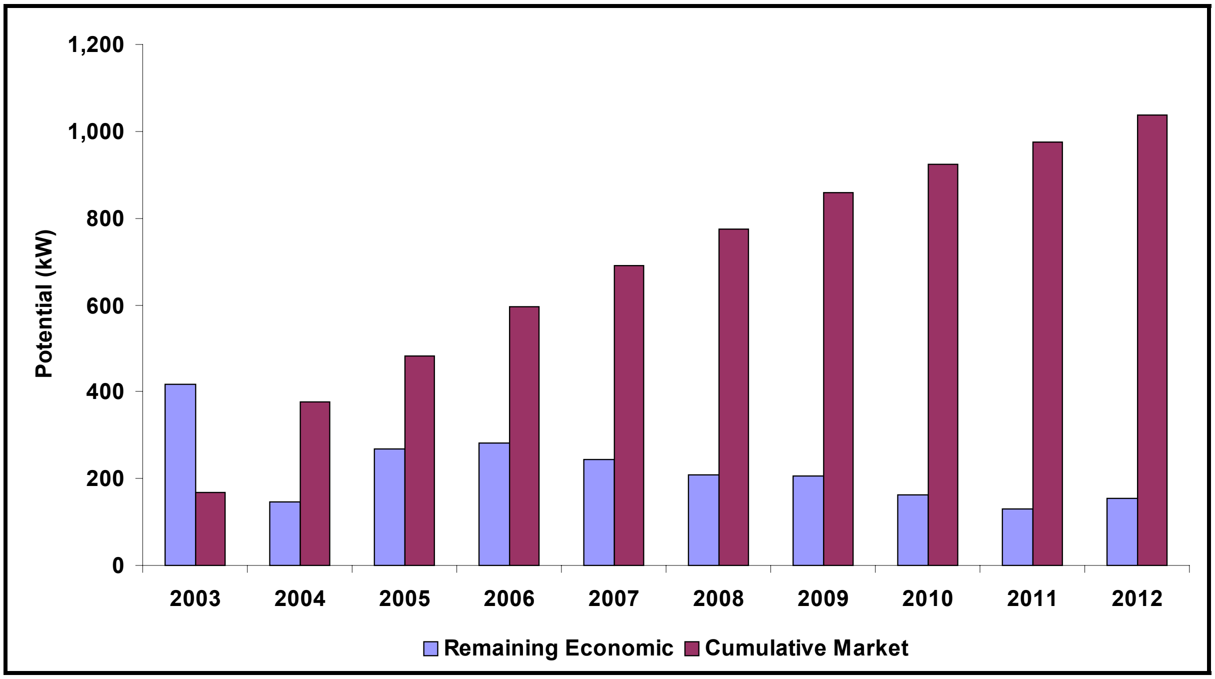


Figure 4-3 illustrates the incremental market potential versus the cumulative market potential for food processing waste biogas within the mini-grid area for the expected case scenario.

Figure 4-3: Expected Case Food Waste Biogas Market Potential

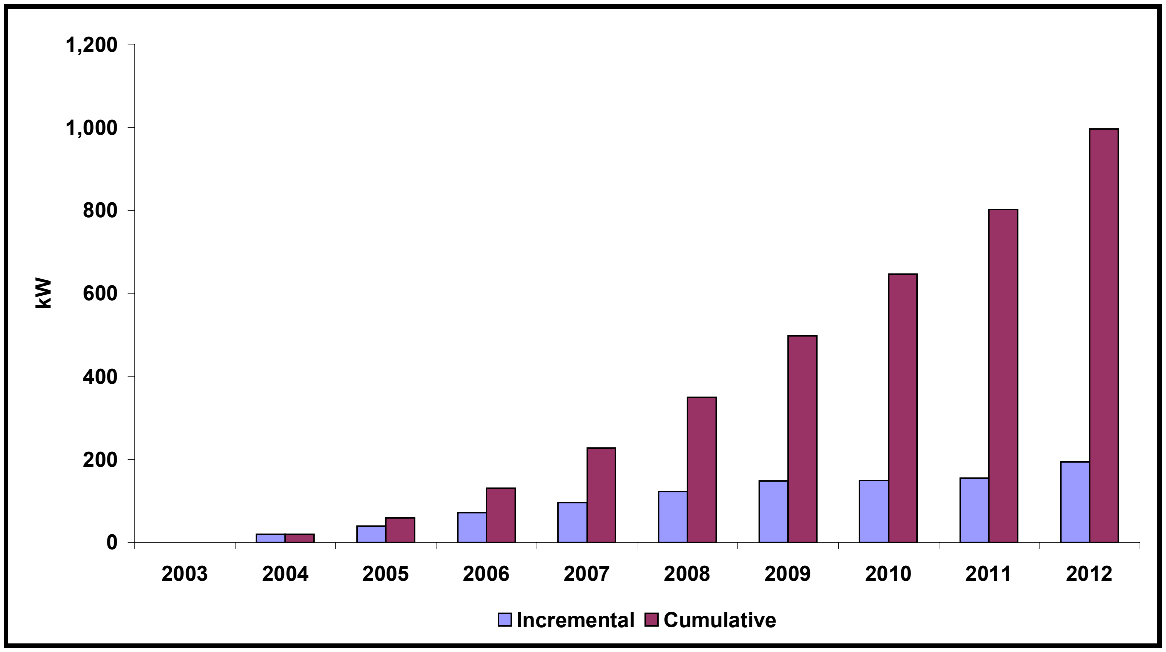
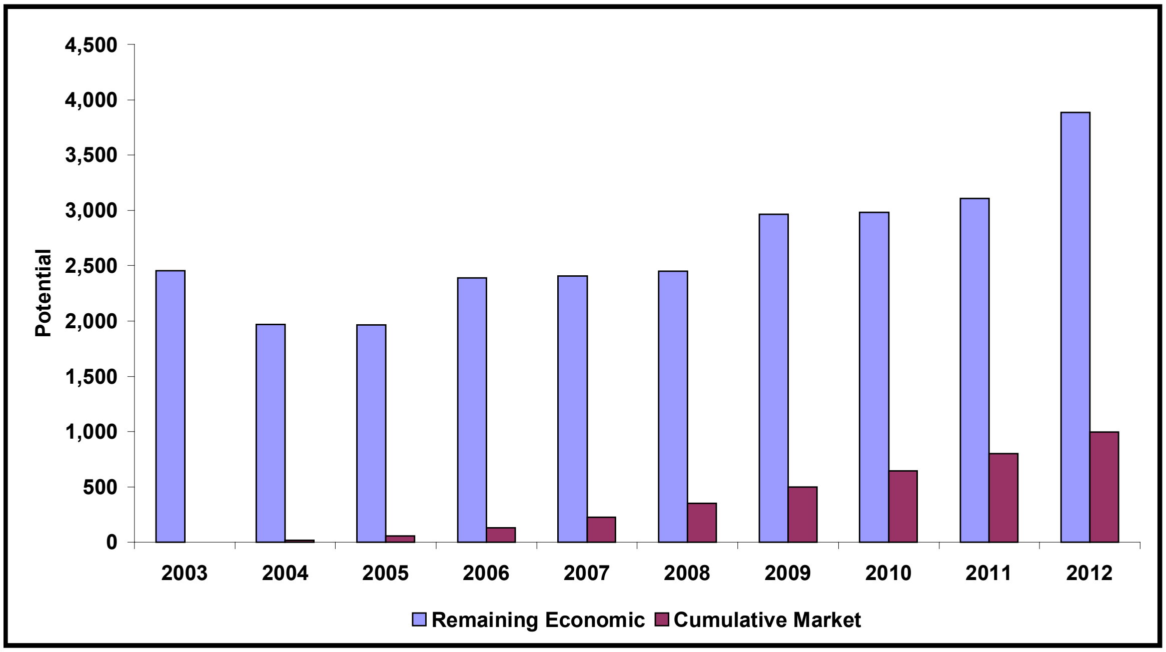


Figure 4-4 illustrates the economic potential versus the cumulative market potential for food processing waste biogas within the mini-grid area for the expected case scenario. Although the projected installed kW generation magnitudes are higher than for the dairy waste resource, market penetration and saturation rates are expected to remain lower than dairy waste as a percentage of the economic potential (see Figure 4-2).

Figure 4-4: Food Waste Economic Vs. Cumulative Market Potential – Expected Case



<u>*Low Scenario*</u>

The *low potential scenario* provides insight into the impact of discontinuing the public support for renewable fueled biogas systems. As mentioned before, this scenario discontinues the investor owned utility SGIP application rebates in January 2005 as currently scheduled by the CPUC. No other adjustments to the economics relative to the expected case have been made in this assessment. The results for dairy and food processing are shown in Table 4-7 and Table 4-8, respectively. The first two years results (2003 and 2004) are the same as the expected case, but then fall to nearly half of the expected case potential in the later years.

Table 4-7: Low Case Dairy Biogas Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	6,300	6,300	418	167	167
2004	5,950	5,783	295	118	285
2005	5,556	5,271	142	57	342
2006	5,163	4,820	126	50	393
2007	4,769	4,376	135	54	447
2008	4,375	3,928	122	49	495
2009	3,981	3,486	103	41	536
2010	3,588	3,051	110	44	581
2011	3,194	2,613	87	35	615
2012	3,150	2,535	81	32	648

Note: Current existing operational capacity is 250 kW within the Chino Basin Mini-Grid.

Table 4-8: Low Case Food Waste Biogas Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	37,000	37,000	2,457	0	0
2004	37,000	37,000	1,968	20	20
2005	37,000	36,980	1,079	22	41
2006	37,000	36,959	1,077	32	74
2007	37,000	36,926	1,311	52	126
2008	37,000	36,874	1,350	68	194
2009	37,000	36,806	1,345	67	261
2010	37,000	36,739	1,746	87	348
2011	37,000	36,652	1,736	87	435
2012	37,000	36,565	1,726	86	521

High Scenario

A high economic and market potential scenario has been developed that reflects what development might occur, should regulatory/environmental and market conditions change and become more directly supportive of dairy/food waste based biogas to energy technologies. This scenario also assumes capital costs drop more quickly than in the expected case. Instead of a 2% annual decrease, these costs drop by 2.5% per year. O&M costs also decrease more quickly, increasing the rate of decline between 2003 and 2012 from

1% to a 2% reduction per year. SGIP rebates are assumed to continue beyond 2004 (in accordance with existing pending legislative bills) through the 10 year planning horizon. In addition, it is assumed that with the improved economics the "known PIER Program-related installed kW capacity" would likely increase to 800 kW in 2004. The results for the high potential scenario are summarized in Table 4-9 and Table 4-10, for dairy and food processing waste biogas resources, respectively.

Table 4-9: High Case Dairy Biogas Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	6,300	6,300	0	5,043	2,017	2,017
2004	5,950	3,933	800	1,946	779	3,596
2005	5,556	2,761	0	1,654	661	4,257
2006	5,163	1,705	0	678	271	4,528
2007	4,769	1,053	0	107	43	4,571
2008	4,375	870	0	5	2	4,573
2009	3,981	789	0	5	2	4,575
2010	3,588	708	0	12	5	4,580
2011	3,194	625	0	14	6	4,585
2012	3,150	610	0	21	9	4,594

Note: Current existing operational capacity is 250 kW within the Chino Basin Mini-Grid.

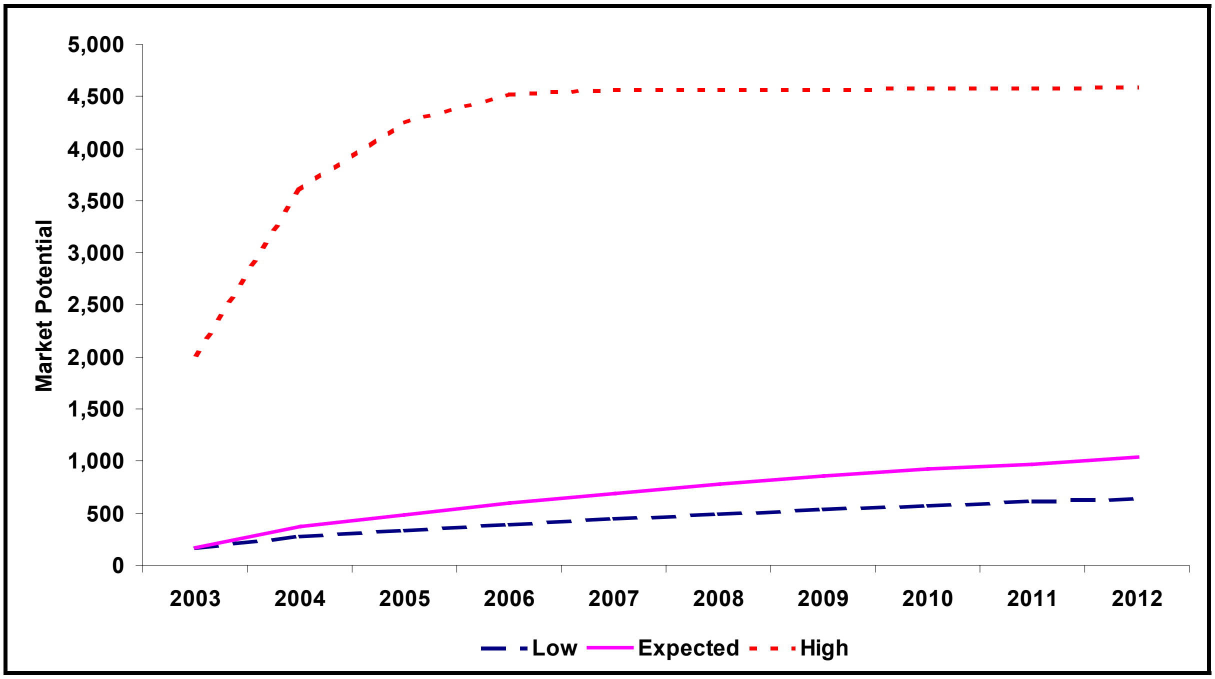
Table 4-10: High Case Food Waste Biogas Economic and Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	37,000	37,000	3,700	0	0
2004	37,000	37,000	3,715	37	37
2005	37,000	36,963	4,311	86	123
2006	37,000	36,877	5,108	153	277
2007	37,000	36,723	5,100	204	481
2008	37,000	36,519	5,877	294	774
2009	37,000	36,226	6,589	329	1,104
2010	37,000	35,896	7,418	371	1,475
2011	37,000	35,525	7,349	367	1,842
2012	37,000	35,158	8,201	410	2,252

The results for all three dairy waste biogas market potential scenarios are illustrated in Figure 4-5. The high case scenario shows the pronounced impact that avoided groundwater cleanup costs can potentially have on the economics of dairy CAD if the owner is responsible for the cleanup. Avoided groundwater cleanup costs were not included in the low and expected case scenarios. Note that the market adoption rate was kept constant across all three scenarios. The effect of including these other environmental avoided costs is that all of the technical potential (e.g., 100%) is then considered economic.

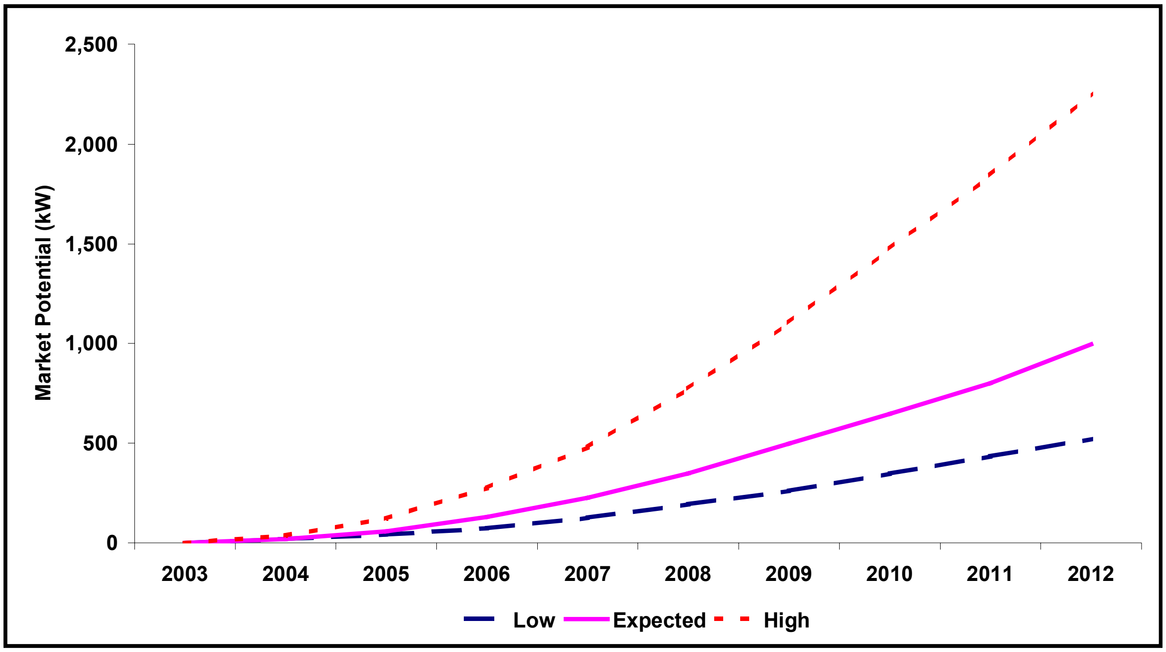
GHG emissions credits were also added to the high case scenario and not the others. The impact of these emissions credits was very small in comparison to the avoided groundwater cleanup costs.

Figure 4-5: Dairy Biogas Market Potential Scenarios



The results for the food waste biogas market potential scenarios are illustrated in Figure 4-6. For food waste biogas production, there are several financial issues that drove the realized market potential. Regardless of how cost effective the technology proves to be, there will be a period of time where the technology must be proven before the market will begin to adopt it. This is illustrated in Figure 4-6 by the non-linear rate of increase in market potential over time for all three scenarios. It is not clear at this time whether the market will develop as stand alone food processing waste digesters or as mixed waste (food processing waste mixed with dairy waste and or waste water treatment) plants. The benefits from mixed waste CCD would suggest this to be the more likely technology.

Figure 4-6: Food Waste Biogas Market Potential Scenarios



5

Wastewater Treatment Plant Biogas Market Potential

5.1 Introduction

The growth of residential and commercial buildings alone within the Chino basin has resulted in a significant increase in demand for wastewater treatment. This growth in wastewater treatment demand has created a significant additional biogas resource in the basin. The assessment of wastewater treatment (WWT) plant biogas economic and market potential within the Commonwealth mini-grid area is discussed in this section. Technical potential results from a previous task are augmented with economic and market information to estimate the quantity of WWT biogas to energy electrical generation capacity that will be installed over a 10-year period from 2003 through 2012. These estimates of market potential have been evaluated under three scenarios: 1) expected case, 2) low development, and 3) high development market conditions.

5.2 Key Issues

The primary issue concerning the use of WWT biogas as a fuel for distributed generation is making it a clean and cost effective fuel relative to natural gas. This involves improving the biogas production efficiency from the wastewater treatment/digestion processes to cleaning the resulting biogas, so as to reduce emissions and improve the reliability and energy conversion efficiency of electricity production. The potential benefits are significant to both the wastewater treatment process and to the environment. These benefits include improved destruction of wastewater solids, enhanced destruction of pathogens, decreased reliance on purchased energy from the grid, and improved local air quality.

A key issue in the process of developing the WWT market potential within the Chino mini-grid was that there are a limited number of locations where WWT biogas to energy can be implemented. One option would be to perform the market potential assessment on a site-specific basis. However, this level of sophistication and detail is beyond the scope of this project and therefore a more generalized probabilistic approach is used. Instead of determining if a single incremental biogas project at a given WWT facility will or will not be technically and economically feasible, the approach used in this market assessment determines a result that is analogous to a probability-weighted market potential in terms of gross generation capacity (kW).

5.3 Development of Prototypes

There are two biogas facility prototypes that were developed for this analysis. Their choice was greatly influenced by the four WWT plants that currently reside within the Commonwealth renewable energy mini-grid area. At present, all four WWT facilities have onsite supply of self-generated electricity. None of these facilities are currently net sellers of electricity under contract with a power purchaser. The installed generation capacity at these facilities for the most part is sufficient to handle the expected growth in biogas production resulting from incremental onsite AD operations. Only one facility is expected to need additional generation within the ten year planning horizon of this market potential assessment. As a result of this lack of need for incremental generation and the relatively small amount of net technical potential[1] that exists, the options are limited relative to enhancement technologies, with only a small amount of new on-site electric generation in the future.

The first prototype considered involves a combination of enhanced WWT biogas production and enhanced electricity production. These options are considered together in a single prototype due to the limited overall technical potential. There is also some logic in considering the two enhancements together as they are both designed to optimize the energy output of the biogas to electricity production facility. Based on information about the four WWT plants and judgments by the Commonwealth Team regarding the amount of biogas that could be produced through enhancements and the likely sizing of electric generation equipment, it is assumed that this prototype facility has 70% of its electric load served by self-generation. Of this, approximately 45% is fueled by biogas and 55% by natural gas. The enhancements increase biogas production by 60%. It is assumed in the analysis that net electric generation increases by 10% and all of the natural gas used to co-fuel the self-generation is replaced by the additional biogas production. The major economic benefits are the avoided cost of purchased natural gas used to partially fuel the existing generators and the avoided cost of retail electricity purchases due to increased generator output.

The second WWT biogas facility prototype involves the addition of new generation for the purposes of taking advantage of biogas production that might otherwise be flared. This prototype does not look at the anaerobic digestion processes, as it is assumed that they will have already been enhanced due to other ongoing activities. It includes the cost of new electric generation equipment, plus the cost of enhanced generation production similar to the

[1] Net Technical Potential is the gross technical potential, less any existing potential that has been installed to date.

first prototype. This prototype represents only an incremental increase in generation capacity. Within the Chino mini-grid area, there is a need for additional electric generation in 2010. It is assumed that prior to this year no technical potential for new on-site generation exists. The annual capacity factor for this new generation prototype is estimated at 70% under all scenarios. This value is most likely generous, given that any new generation facilities would not be expected to run anywhere near full load, unless outside energy purchase agreements were arranged with SCE or other ESPs. This prototype is included in order to capture the incremental increase of biogas production due to the planned growth in wastewater treatment requirements in the mini-grid area.

These systems are based upon present known characteristics of the IEUA facilities. Because these digesters were already in existence, this was a logical and realistic assumption. Therefore, the prototypes are existing systems that have enhancements added.

5.4 Estimates of Technical Potential

The technical potential for installation of WWT biogas to energy facilities in the mini-grid was explored under a separate Planning and Analysis Project task[2]. In this report, technical potential estimates were developed for 11 WWT facilities of which four are located within the Commonwealth Renewables Mini-grid. These estimates provided in the WWT Biogas Inventory Report were based on a projected 47% increase in efficiency of biogas production over existing baseline production levels. More recent information from the report's authors indicates that higher production rates are clearly possible through further technology enhancements. For this analysis it has been assumed that the WWT facility prototype enhancements will achieve a 60% increase in biogas production over existing levels at these facilities.

Existing WWT Distributed Generation Facilities

At present, the four WWT plants in the mini-grid have an installed base of self-generation totaling 4,960 kW. A portion of this existing generation is already fueled by biogas. The issue here is what is the biogas generation potential above the existing level of realized biogas generation. In addition, the potential needs to be defined according to how much of the biogas production can be handled by pre-existing generation and how much requires new generation equipment to be installed.

The second and third columns of Table 5-1 illustrate the generation potential from existing biogas production as well as that from incremental biogas production resulting from AD enhancements at the mini-grid WWT plants. This requires that the total cumulative biogas

[2] Inventory Report for Sewage Treatment Plants in the Chino Study Area, by CH_2M Hill for the California Energy Commission's Commonwealth PIER Renewable Affordability Mini-grid Program, October 2002.

production potential be quantified. The cumulative biogas potential is the sum of the current biogas production and the incremental biogas production from enhancements. The cumulative biogas potential is shown in the fourth column of Table 5-1. The fifth column shows the installed and planned generation capacity at the WWT plants projected over the planning horizon. What is apparent from Table 5-1 is that there is no need for new generation equipment until the later years of the planning horizon. The existing generation satisfies most of the increases in biogas production until that time.

Table 5-1: Projected WWT Biogas-Fueled Generation within the Mini-grid

Year	Existing Generation currently fueled by biogas (kW)	Incremental Potential Fueled from Enhancements (kW)	Cumulative Technical Potential (kW)	Projected Installed Capacity (kW)
2003	2779	1667	4446	6780
2004	2976	1786	4762	7760
2005	3174	1904	5078	7760
2006	3372	2023	5395	7760
2007	3569	2142	5711	7760
2008	3842	2305	6148	7760
2009	4116	2469	6585	7760
2010	4389	2633	7022	7760
2011	4662	2797	7460	7760
2012	4935	2961	7897	7760

Remaining WWT Biogas Technical Potential

The technical potential estimate for this market assessment is based upon the biogas production potential that is over and above the existing level. The remaining incremental potential for these four facilities located within the mini-grid is shown in the second column of Table 5-2. These estimates represent a 60% increase in biogas production from enhancements. This also represents the electric generation potential from the gas production and generation system enhancements. The installed capacity at these four facilities at the start of 2003 is 4,960 kW. With the addition of 2,600 kW of planned new generation at one of the facilities during 2003 and 2004, this increases to 7,760 kW of installed capacity in 2004 as shown in Table 5-1. Note that the existing generation is not entirely fueled by biogas, and the electricity produced does not supply all of the WWT facilities' needs. As a result, any enhancements to biogas production will have the effect of fuel switching to renewable biogas fuel first and foremost.

This market potential analysis is intended to provide a high level assessment. Many specific details of the WWT facilities in the mini-grid are not known and generalized assumptions have been made instead. One such assumption is that there is a net electric generation increase of 10% resulting from the process enhancements. This is based on existing information that suggests that the WWT plant loads are not optimally served by the existing generation. In addition, it is assumed that all of the natural gas currently used to co-fuel the self-generation can be replaced by biogas.

In 2010, it is expected that an additional 100 kW to 200 kW[3] of new generation should be added to utilize the biogas resulting from the growth of wastewater treatment effluent in the mini-grid area. This is reflected in the market potential analysis by adding 100 kW in the low case scenario, 150 kW in the expected case scenario and 200 kW in the high case scenario. The effective *Remaining Gross Technical Potential* shown in the fifth column of Table 5-2 represents the total biogas to energy system capacity by year that could be installed without regard to cost-effectiveness or other market constraints. These estimates represent the starting point for the market potential assessment covered by this task activity and report. The majority of the technical potential in the second column of Table 5-2 is realized by substituting the natural gas that is currently used to partially fuel the existing electric generation onsite. It is not until 2010 that any technical potential for new WWT biogas fueled generation is estimated to exist.

[3] Currently planned at one of the WWT plants within the mini-grid.

Table 5-2: Mini-grid WWT Biogas Technical Potential

Year	Incremental Potential Fueled from Enhancements (kW)	Incremental Potential Above Current Biogas Generation (kW)	New Generation Potential Fueled by Biogas (kW)	Remaining Technical Potential (kW)
2003	1667	167	0	167
2004	1786	179	0	179
2005	1904	190	0	190
2006	2023	202	0	202
2007	2142	214	0	214
2008	2305	231	0	231
2009	2469	247	0	247
2010	2633	263	100/150/200	363/413/463
2011	2797	280	100/150/200	380/430/480
2012	2961	296	100/150/200	396/446/496

Note: 100 kW of New Generation fueled by Biogas is added in the low case scenario, 150 kW is added in the expected case scenario and 200 kW is added in the high case scenario.

5.5 Analysis of Economic and Market Potential

Economic and market potential will first be examined from the perspective of the most likely or expected set of conditions. A low potential scenario assessment and then a high potential scenario will follow this expected case. Some of the financial characteristics that can separate the low, expected, and high market development scenarios include: changes in capital costs over time, electric retail rates and wholesale natural gas and electric market prices, and other state and federal incentives such as performance-based incentive payments and capital cost buy down payments. As mentioned earlier, fuel switching is a major component of this analysis. This analysis is intended to identify the *net increase* in electric generation in order that the *net electric grid impacts of WWT biogas* can be assessed in the Power Flow Analysis task of this Commonwealth Program Planning and Analysis Project.

Data Sources

A number of sources for necessary data were collected and used for this analysis. The data includes projected natural gas rates. The natural gas tariffs from Southern California Gas Company (SCG) applicable for these WWT facilities were used to develop current marginal gas prices. Natural gas prices have been very volatile and so have forecasts of prices. For this reason, it is assumed that in the expected and high case scenarios, natural gas prices are constant in nominal dollars for the entire planning horizon.

Future electricity prices were developed with the use of current average electricity prices experienced at the four WWT facilities, combined with the future price trends obtained from the CEC's Electricity Outlook 2002-2012 report.

To get an understanding of the system costs associated with enhanced anaerobic digestion technology and the associated electric generation costs, a number of sources were examined. The primary source for these system costs resulted from conversations and e-mail exchanges with the authors (CH_2M Hill) of the earlier Planning and Analysis Project task report on WWT biogas resources within the mini-grid.

Analytic Methodology

Each prototype was developed using a set of expected system costs. These were subsequently used along with expected facility revenue streams to provide a cash flow analysis over a ten year planning horizon. The cash flow analysis was used to compute the internal rate of return (IRR) for each prototype for each of the ten years of the analysis. The project measure of performance (IRR) was then used to determine the remaining technical potential that was economic. Finally, a market adoption model was employed to determine the market potential for each year of the assessment.

System Costs

For enhanced biogas production, not including prime mover and electric generation equipment, the costs were assumed to $1,500/kW in 2003 dollars. The enhanced biogas production system is comprised of technologies such as thermal and mechanical hydrolysis and advanced energy recovery as well as biogas cleaning equipment. The ultrasound (mechanical hydrolysis) was assumed to cost $750 per kW. The thermal hydrolysis was assumed to cost $1,250 per kW. The advanced heat recovery (organic rankine cycle) was assumed to cost $3000 per kW applied to 10% of the capacity for an effective cost of $300 per kW. The gas pretreatment was assumed to cost $200 per kW. The costs of the two-hydrolysis systems were averaged and the other component costs added to arrive at $1,500 per kW. New enhanced generation costs were estimated to be $3,250/kW. This includes $2,000/kW for the generation equipment alone. These cost assumptions do not vary across the expected, low, and high potential scenarios in the base year. The only capital costs that were varied over the planning horizon for the different scenarios were for the enhanced biogas production prototype in the low potential scenario.

O&M costs for the enhanced AD processes are assumed to be $0.010/kWh, whereas O&M costs for the new generation is assumed to be $0.0165/kWh. These costs vary over the planning horizon depending on the scenario, with the exception of enhanced AD in the low potential scenario. In this case the O&M costs were assumed to be double ($0.020/kWh).

Value of Generated Power

The forecast of retail prices of natural gas and electricity used in the economic potential analysis are summarized in Table 5-3, along with the estimated value of green tags for biogas projects. All values are expressed in 2003 dollars.

The retail cost of avoided natural gas purchases was based on gas rates, commodity, and delivery for self-generation. The actual cost that the four WWT facilities are currently paying was not known at the time of this analysis. In the expected case and high potential scenarios, the gas rate is assumed to remain flat over time. In the low potential scenario, the price has been forecasted using the same trend in electric prices forecasted in the CEC's Electricity Outlook Report. Natural gas prices are currently assumed to decline over the 10-year planning horizon and then stay flat beyond 2012.

Table 5-3: Estimated Values of Natural Gas and Generated Electricity

Year	Gas Rate Low / Expected & High ($/therm)	I-6 Electric Rate Low & Expected / High ($/kWh)	Green Tag Value ($/kWh)
2003	0.77 / 0.77	0.104 / 0.104	0.005
2004	0.77 / 0.77	0.102 / 0.102	0.005
2005	0.76 / 0.77	0.086 / 0.086	0.005
2006	0.76 / 0.77	0.074 / 0.074	0.005
2007	0.75 / 0.77	0.072 / 0.072	0.005
2008	0.74 / 0.77	0.070 / 0.070	0.005
2009	0.73 / 0.77	0.066 / 0.070	0.005
2010	0.73 / 0.77	0.064 / 0.70	0.005
2011	0.72 / 0.77	0.063 / 0.070	0.005
2012	0.71 / 0.77	0.058 / 0.070	0.005
2013	0.71 / 0.77	0.057 / 0.070	0.005
2014	0.71 / 0.77	0.057 / 0.070	0.005
2015	0.71 / 0.77	0.057 / 0.070	0.005
2016	0.71 / 0.77	0.057 / 0.070	0.005
2017	0.71 / 0.77	0.057 / 0.070	0.005
2018	0.71 / 0.77	0.057 / 0.070	0.005
2019	0.71 / 0.77	0.057 / 0.070	0.005
2020	0.71 / 0.77	0.057 / 0.070	0.005

Cash Flow Modeling

Both prototypes were modeled assuming installations occur over the years 2003 through 2012. Unlike the dairy and food processing waste biogas market potential assessment, WWT biogas potential was not run with differing ownership and operating schemes. Based upon reported experience in this market segment, in all cases it has been assumed that the ownership will be a public agency. Also, capital costs are based on a single set of expected values. The degree to which costs change over time may vary but the base year costs (i.e., 2003) are fixed.

Financing is fixed across the three scenarios. It has been assumed that the owners will finance 100% of the capital costs. Loan or bond financings are assumed to have an interest rate of 8% and a term of 20 years. No tax credits are taken as the ownership is assumed to be public in all cases. California SGIP incentives are assumed to exist *for the incremental generation facilities only* in the expected case for all years.

Inflation is assumed to be 3% per year, in all years and for all three scenarios. Several factors in the economic potential assessment are varied across the three economic potential scenarios. This cash flow analysis is performed for each of the 10 years in the planning horizon.

In the low potential scenario, several conditions have been assumed to be different as compared to the expected case. Capital and O&M costs do not vary over time. In nominal terms, these costs stay constant for all years in the planning horizon. This is true for both WWT prototypes. In the case of the new generation, it is assumed that the SGIP incentives will not be available beyond 2004, as currently scheduled in the original CPUC Decision that created the incentive program. The generation capacity factor for both prototypes is assumed to be 85% in all years, just as in the expected case scenario.

In the high potential scenario, several factors are adjusted. For both prototypes it is assumed that the price of offset electricity declines as in the expected case until 2007, where it remains flat in nominal terms. Capital costs for the enhanced biogas production and generation prototype are assumed to decline at a rate of 2.5% per year, instead of 2% per year as in the expected case. Capital costs for the biogas enhancement technologies associated with the new generation are assumed to decline at a rate of 1% per year, as opposed to being flat as in the expected and low scenarios. The capital costs for the biogas generation equipment itself were not assumed to decline at all as this is a mature technology.

The capacity factor for the electricity generation from the first prototype -- *enhanced biogas and electric production* is assumed to improve over time due to improvements in technology and operating practices. The capacity factor increases from 85% in 2003 up to 90% by 2008. As mentioned earlier, the capacity factor for the new generation is always assumed to be 85%.

The modeling process involves running each prototype for each year using the assumptions associated with each of the three scenarios. The internal rate of return (IRR) is determined through iteration for each scenario for each year. The results of this analysis are considered to be the technical potential that is cost effective based on public ownership. Once again, this cost-effective potential is analogous to a probability-weighted estimate of the economic potential and not an actual number of WWT plants developed. To illustrate, the expected case IRR results for both prototypes are shown in Table 5-4.

Table 5-4: Expected Case IRR Results

	1st Prototype (Enhanced Existing)		2nd Prototype (New System)	
Year	IRR (%)	Economic Potential (%)	IRR (%)	Economic Potential (%)
2003	39.95	100	0.00	0
2004	40.10	100	0.00	0
2005	40.60	100	0.00	0
2006	41.42	100	0.00	0
2007	42.24	100	0.00	0

2008	43.06	100	0.00	0
2009	43.95	100	0.00	0
2010	44.88	100	31.00	100
2011	45.82	100	30.16	100
2012	46.94	100	30.04	100

When the IRR goes above 28.00% the economic potential reaches 100% in all cases. As is evident from the table, the economic potential of both prototypes in the expected case is always 100%.

<u>*Calculation of Market Potential*</u>

The market potential model is discussed in Chapter 2 of this report. For WWT biogas, the market penetration rate was assumed to be 40% per year for the expected case, 5% per year for the low case, and 90% for the high case. Normally for an analysis such as this, these expected and high case adoption rates would be considered unrealistic. In addition, some lead-time is typically assumed from the point a decision is made to move forward with a project to the point it is completed and begins operation. However, because there is only one public agency making decisions on the adoption of WWT biogas technologies for a very limited number of facilities within the mini-grid, this lead-time is assumed to be very short. It is believed that the public agency's attitude will have a significant impact on market adoption and this situation should enter into the market assessment. If the attitudes towards efficiency improvements and renewable energy development were not strong, then there would not be a strong preference for adoption. This is the basic assumption in the low potential scenario. On the other hand, if attitudes and interest towards renewable energy were strong, then there would be a much stronger preferences for adoption. This is the assumption basis in the high potential scenario.

Economic and Market Potential Results

The analysis results for each of the three established economic and market potential scenarios of the two prototypes are presented below.

<u>*Expected Scenario*</u>

Table 5-5 shows the results from the expected economic and market potential analysis. This scenario represents the wastewater treatment biogas gross technical potential expected to be economic within the mini-grid and subsequently adopted. What is most obvious is that the economic potential is the same as the net technical potential. Under the assumptions established for this scenario, it is always economic to perform the enhancements and add future generation. The average IRR was estimated to be nearly 40%.

Table 5-5: WWT Biogas Incremental Economic and Market Potential – Expected Case

Year	Remaining Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	167	167	167	67	67
2004	179	112	112	45	111
2005	190	79	79	32	143
2006	202	59	59	24	167
2007	214	47	47	19	186
2008	231	45	45	18	204
2009	247	43	43	17	221
2010	413	192	192	77	298
2011	430	132	132	53	351
2012	446	95	95	38	389

The incremental and cumulative market potential results in Table 5-5 are presented graphically in Figure 5-1.

Figure 5-1: WWT Biogas Incremental Market Potential – Expected Case

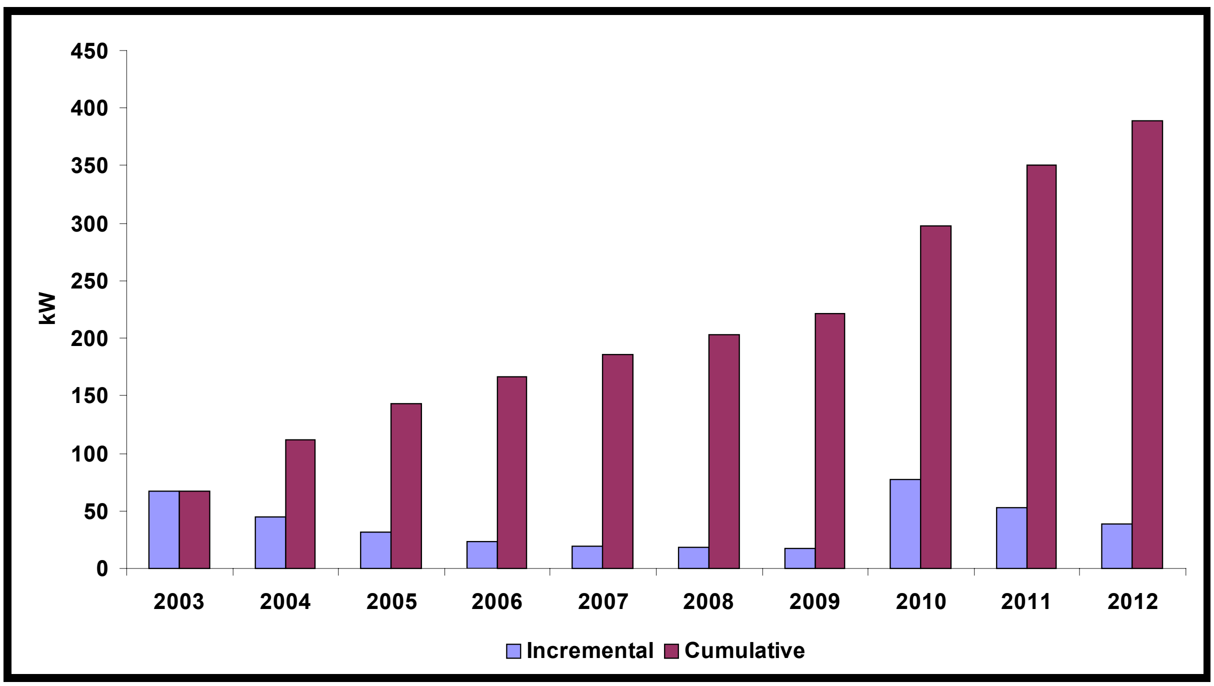
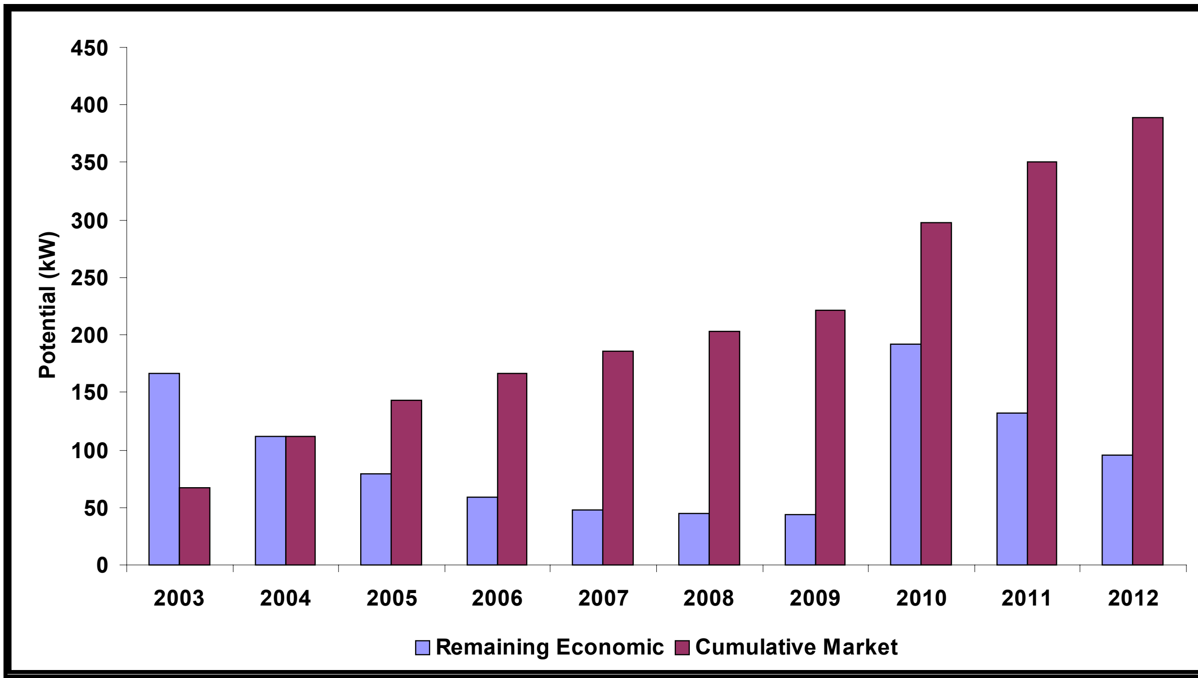


Figure 5-2 illustrates the economic potential versus the cumulative market potential for WWT biogas within the mini-grid area for the expected case scenario.

Figure 5-2: WWT Economic Potential versus Cumulative Market Potential – Expected Case



In 2010, the remaining economic potential increases abruptly. This is due to the expected need for new WWT biogas fueled generation at that point in time at one of the WWT plants within the mini-grid.

Low Scenario

The low economic and market potential scenario provides insight into the impact of discontinuing the public support for renewable biogas systems, notably the removal of SGIP incentives for new generation after 2004. This case assumes that capital costs for the first prototype increase by $1,000/kW in nominal terms and O&M costs are doubled that of the expected case. The results are shown in Table 5-6.

Table 5-6: Low WWT Economic and Incremental Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	167	167	84	4	4
2004	179	174	74	4	8
2005	190	183	77	4	12
2006	202	191	80	4	16
2007	214	198	84	4	20
2008	231	211	73	4	24
2009	247	223	77	4	27
2010	363	336	147	7	35
2011	380	345	142	7	42
2012	396	354	144	7	49

High Scenario

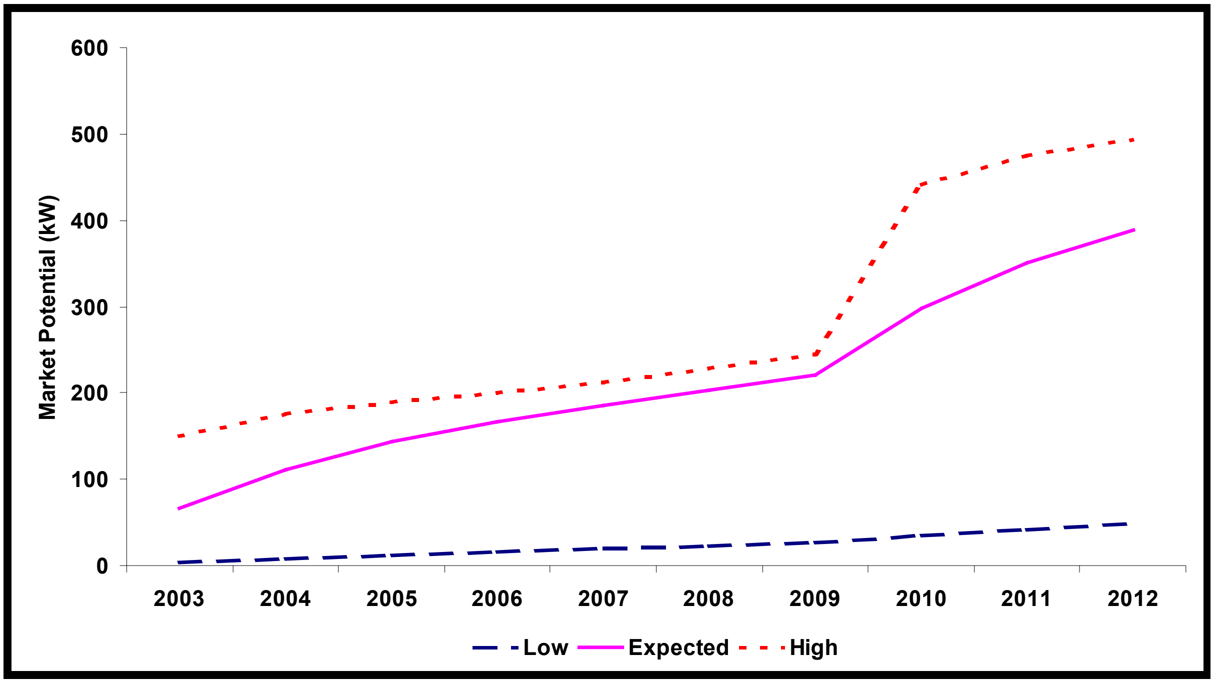
The high economic and market potential scenario has been developed to reflect what might happen should market conditions change and become more supportive of biogas to energy technologies. The results are shown in Table 5-7. What is immediately apparent is that the economic potential under this scenario is the same as in the expected case scenario. Under the assumptions for this scenario, the technical potential is always cost effective.

Table 5-7: High WWT Economic and Incremental Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	167	167	167	150	150
2004	179	29	29	26	176
2005	190	15	15	13	189
2006	202	13	13	12	201
2007	214	13	13	12	213
2008	231	18	18	16	229
2009	247	18	18	16	245
2010	463	218	218	196	442
2011	480	38	38	34	476
2012	496	20	20	18	494

Figure 5-3 shows a comparison of the cumulative market potential for each of the three scenarios. The impact of new generation beginning in 2010 is very pronounced in the high case scenario and progressively less in the expected case the low case scenarios. It is also apparent that potential in the expected case begins to catch up with that if the high case until 2010. This is because the market adoption rate is higher in the high case causing the potential to be realized earlier. The economics were not responsible for the difference, as all of the technical potential was determined to be economic in both scenarios. In the low scenario, the realization of the potential never takes off due to not only less favorable energy prices, but also the less favorable capital and O&M costs and market adoption rate.

Figure 5-3: WWT Biogas Incremental Market Potential by Scenario



6

Landfill Gas Market Potential

6.1 Introduction

Landfills have long been a biogas resource for distributed generation. The assessment of landfill gas (LFG) market potential within the Chino Basin mini-grid is discussed in this section. Technical potential results from a previous task are augmented with financial and market information to estimate the quantity of LFG biogas to energy capacity will be installed in future years through 2012. The market potential has been evaluated under three scenarios: expected, low and high market potential.

6.2 Key Issues

Possibly the most important issue for bioreactor landfill projects is that currently it is very difficult to obtain a permit to develop a bioreactor landfill in California.

The second key issue concerns the true viability of the bioreactor concept itself. There is some skepticism as to whether a bioreactor can be successfully developed for an entire landfill. Demonstrating the bioreactor concept on a small pilot cell within a larger landfill is different from developing an entire landfill into a bioreactor.

A key issue in assessing the market potential for landfill gas within the Chino basin electric distribution system mini-grid is that there is only one existing landfill within its boundaries. This landfill has already closed and does not accept any new waste, which does not make it a viable candidate for a bioreactor application. One of the criteria for selecting a landfill for performing a bioreactor pilot was that it had to be currently active and remain open for at least four more years. The purpose of this criterion is so the landfill operations can take advantage of all the benefits a bioreactor affords. Several of the benefits are incurred during the time when a landfill is accepting waste, in particular the ability to accept more waste than a standard landfill. Because the only landfill in the mini-grid is closed, a hypothetical landfill needed to be developed for purposes of evaluation of the mini-grid power flows. The landfill bioreactor incremental biogas generation could have been ignored in this market assessment but because of the size of the generation that might have been developed, the decision was made to treat landfill biogas hypothetically. In other words, the market potential assessment will look at what might have been developed incrementally and provide this input to the ZECO Power Flow Modeling task so that the impact of such a project can be effectively evaluated on the system.

6.3 Development of Prototypes

The prototype for landfills in the mini-grid has some issues as mentioned above. Because the Commonwealth Program seeks to pilot a landfill bioreactor, the only prototype to be considered here is a bioreactor. The existing landfill has generation scheduled to go online in 2003. The assumption for the bioreactor is that this existing generation could be doubled in size, since a bioreactor is capable of increasing the biogas production in the landfill by a factor of 2 to 3. Doubling the biogas production and therefore the generation capacity is a reasonable assumption to make for the purposes of this market potential assessment.

The bioreactor itself will require additional leachate collection to be added and enhance gas collection. The generation equipment will need to be doubled in size by the addition of approximately 4,200 kW of internal combustion engine-generators. The life of the facility is assumed to be cut in half from 30 years down to 15 years. It will be assumed that the landfill is still active and scheduled to be open for five more years. The addition of a bioreactor in the first year (2003) will allow the landfill to remain open for an additional five years before closing. This will, in turn, allow electricity to be produced for 25 years. The generation is assumed to be constant over the life of the landfill biogas production.

6.4 Estimates of Technical Potential

The technical potential for landfill biogas to energy within the mini-grid was developed in another task[1] under the Planning and Analysis Project of the PIER Commonwealth Program. The technical potential remains flat throughout the 10 year planning horizon and will not begin to fall off due to declining gas production until well after this period. The technical potential is shown in Table 6-1.

[1] Task 1.1.3 - Inventory Report for Potential Landfill Bioreactors.

Table 6-1: LFG Technical Potential

Year	Technical Potential (kW)
2003	8,400
2004	8,400
2005	8,400
2006	8,400
2007	8,400
2008	8,400
2009	8,400
2010	8,400
2011	8,400
2012	8,400

6.5 Analysis of Economic and Market Potential

Because there is only one landfill, the possibility existed that no market potential for LFG would result from this analysis. For this reason, the overall market potential assessment takes on a more probabilistic approach. Instead of determining if a single landfill will or will not be economical, the approach will determine something analogous to a probability weighted market potential. This is accomplished by computing the IRR and then applying the expected hurdle rate distribution, as discussed in section 2 of this report, to determine the probability of market adoption.

For this analysis, economic potential will first be examined from the perspective of the most likely or expected set of conditions. Normally a low potential scenario and then a high potential scenario would follow this. Characteristics that can separate the low, expected, and high scenarios include capital costs over time, electric retail and wholesale prices, state and federal tax credits, and other state and federal incentives such as performance payments and capital cost buy down payments.

Because this is purely a hypothetical assessment, as mentioned earlier and does not represent the actual status of the existing landfill within the mini-grid, the high and low economic potential scenarios have not been examined. It is more useful to examine the expected economics of this hypothetical case and then explore what impacts various market conditions can have on the final market potential results.

Regulatory and market conditions play an important role in the adoption of this technology. As a result, three market penetration scenarios have been developed for the same economic conditions. The expected scenario uses a market penetration rate of 5% per year. The low scenario assumes that it is not possible to obtain a permit to construct a bioreactor and therefore the penetration rate is zero. The high market potential scenario assumes the market penetration rate increases over the first several years of the planning horizon due to the general increase in knowledge on bioreactors and the associated increase in acceptance of its application. In this scenario the penetration rate starts at 5% in 2003 and increases to 20% in 2006 and remaining there for the duration of the planning horizon.

Data Sources

A number of sources for necessary data were used. The forecast of wholesale electric prices was derived from the CEC's Electricity Outlook 2002-2012 report.

To gain an understanding of the system costs associated with landfill bioreactor technology and the associated electric generation costs, a few sources of information were identified and mined. The California Energy Commission website contained links to PIER Consultant reports entitled "Economic and Financial Aspects of Landfill Gas to Energy Project Development in California" which lists capital cost and O&M cost information on landfill gas technologies. Other sources include two reports published by the U.S. EPA.[2] [3] In addition, information was obtained from the authors (CH2M Hill) of the landfill inventory report for the mini-grid prepared as part of the PIER/Commonwealth Planning and Analysis Project.

Analytic Methodology

Each prototype was developed using a number of likely system costs. These were subsequently performed over a ten-year planning horizon. In addition, a set of market adoption rates was developed for each of the three scenarios.

System Costs

Bioreactor systems involve enhanced leachate and biogas recovery equipment as well as electric generation equipment. These systems were estimated to cost on average $3,680/kW, of which $2,000/kW is assumed for generation. The landfill generation prototype is assumed to be located at the Milliken landfill. There is now an existing landfill gas generation system that was scheduled to begin operations in the spring of 2003. The system was to have a capacity of approximately 4.2 MW. This planned landfill gas generation system was used as a base upon which the bioreactor prototype was built. As mentioned earlier, the bioreactor itself will require additional leachate collection to be added and enhanced gas collection. These systems are assumed to have an effective combined cost of $1,680 per kW. The

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[2] U.S. Methane Emissions 1990-2020: Inventories, Projections, and Opportunities for Reduction, U.S. Environmental Protection Agency, September 1999.

[3] Emerging Technologies for the Management and Utilization of Landfill Gas, by E.H. Pechan & Associates, Inc., prepared for U.S. Environmental Protection Agency, January 1998.

current generation equipment therefore needs to be doubled in size by the addition of 4.2 MW of internal combustion engine-generators. O&M costs are assumed only for the generation equipment and are estimated to be $0.010/kWh. Both system costs and O&M have been assumed to be flat over time in terms of nominal dollars.

Value of Generated Power

The wholesale price of electricity and the assumed value of Green tags on the sale of this green electricity back into the grid are shown in Table 6-2.

Table 6-2: LFG Electricity Prices

Year	Wholesale Rate ($/kWh)	Green Tag Value ($/kWh)
2003	0.032	0.005
2004	0.029	0.005
2005	0.027	0.005
2006	0.028	0.005
2007	0.030	0.005
2008	0.031	0.005
2009	0.033	0.005
2010	0.034	0.005
2011	0.036	0.005
2012	0.037	0.005
2013	0.037	0.005
2014	0.037	0.005
2015	0.037	0.005
2016	0.037	0.005
2017	0.037	0.005
2018	0.037	0.005
2019	0.037	0.005
2020	0.037	0.005

Cash Flow Modeling

It has been assumed that there are future avoided maintenance costs that start in the future. These avoided costs begin in the first year that they would be avoided. For instance, a normal landfill is assumed to produce biogas for 30 years after closing. If the bioreactor reduces the life of the landfill by 15 years, the avoided cost stream begins in the 16th year and runs through the 30th year. These avoided costs are as a result of the accelerated decay of waste material in the bioreactor.

Private ownership has been assumed for the LFG to energy facility and **no SGIP incentives are assumed**, because the system size is in excess of 1,500kW.

Financing is fixed for this analysis. It has been assumed that the owners have financed 100% of the costs of the bioreactor. In this particular situation, it was assumed that the developer was a private entity and that there would not be any SGIP buydown financing available. Therefore, the developer would be more likely to finance the entire cost to make the economics most attractive. The loan is assumed to have an interest rate of 8% and a term of 15 years. Federal depreciation is taken over 10 years on a declining depreciation schedule whereas the State depreciation schedule is assumed to be 12 years straight. The internal rate of return (IRR) is determined through iteration for each year.

Economic and Market Potential Results

The results for this resource take on an unusual behavior due to the fact that the driving force for this technology is not system costs or energy market prices. The driving force is regulatory in nature. The permitting process has a significant impact. For this reason, and others mentioned earlier, differing economics were not explored. The results shown in Table 6-3 illustrate how the economic potential, ignoring any actual development, change over time. This analysis shows the economics to be very favorable for bioreactor development. The only change in the economic potential is in the first few years. By 2005 all the net technical potential is economic. In the next section, the impacts of differing market adoption scenarios are explored.

Table 6-3: LFG Gross Economic Potential

Year	Gross Economic Potential (kW)
2003	7,081
2004	8,114
2005	8,400
2006	8,400
2007	8,400
2008	8,400
2009	8,400
2010	8,400
2011	8,400
2012	8,400

Expected Scenario

The market potential for landfill biogas reflects the addition of 4,200 kW of known planned generation at the landfill in the mini-grid. This is seen under "Incremental Known Projects" shown in Table 6-4. After this initial introduction of generation the incremental market potential is similar to a probability weighted market potential for bioreactor technology development at the landfill. This analysis does not take into consideration that some lead-time is likely between the time a decision is made to build and the time a facility begins operation. This was done in part because there is only one landfill and also because the incremental market potential is probabilistic in nature.

Table 6-4: Expected LFG Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	8,400	8,400	4,200	2,881	144	4,344
2004	8,400	4,056	0	3,918	196	4,540
2005	8,400	3,860	0	3,860	193	4,733
2006	8,400	3,667	0	3,667	183	4,916
2007	8,400	3,484	0	3,484	174	5,090
2008	8,400	3,310	0	3,310	165	5,256
2009	8,400	3,144	0	3,144	157	5,413
2010	8,400	2,987	0	2,987	149	5,563
2011	8,400	2,837	0	2,837	142	5,704
2012	8,400	2,696	0	2,696	135	5,839

The results of Table 6-4 are graphically shown in Figure 6-1.

Figure 6-1: Expected LFG Market Potential

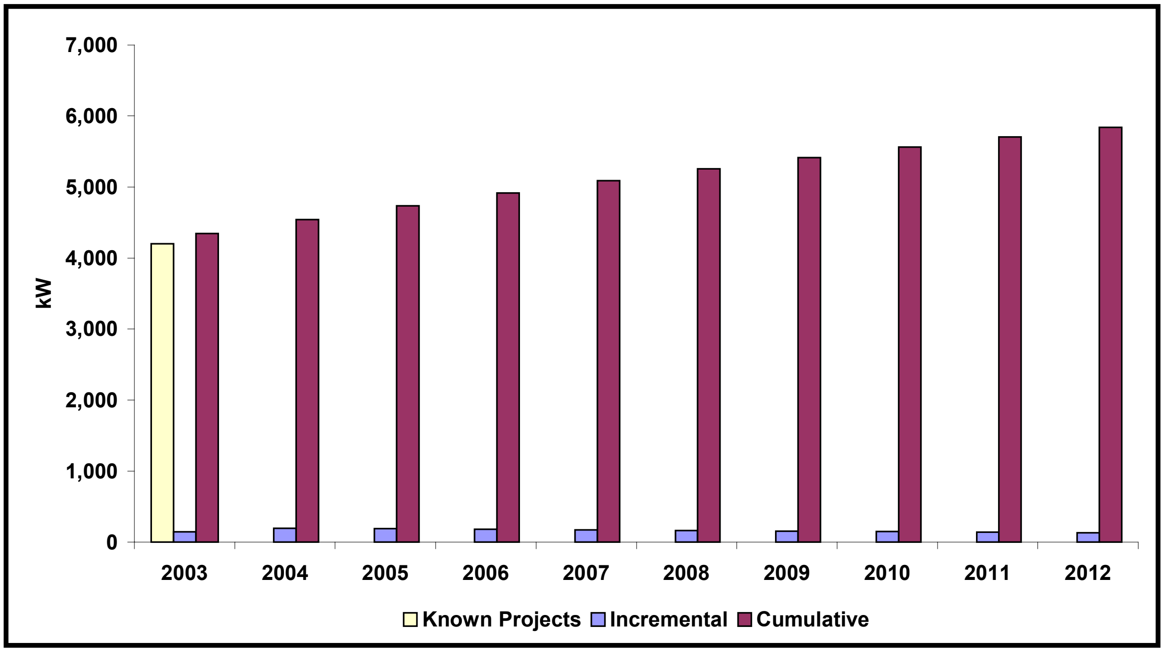
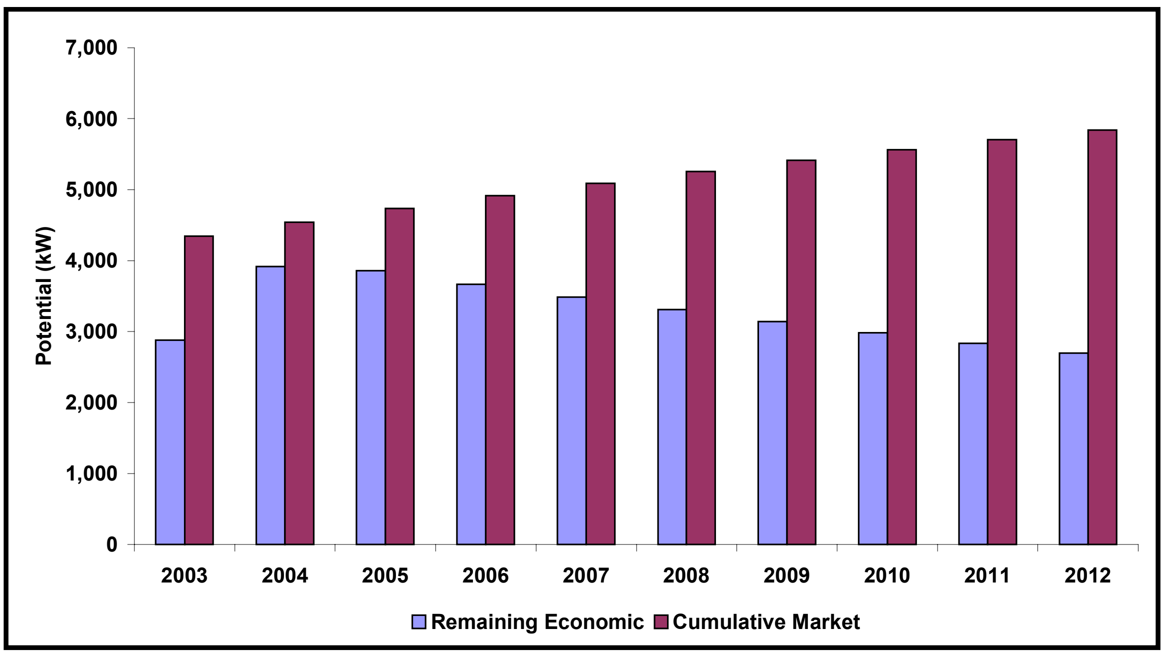


Figure 6-2 illustrates the economic potential versus the cumulative market potential within the mini-grid area for the expected case scenario.

Figure 6-2: LFG Economic Potential versus Cumulative Market Potential



Low Scenario

In this scenario, the only factor that changes from the expected case is that the market adoption rate or market potential fraction is assumed to be zero. This condition might exist if permitting requirement prevents the owner of the single facility within the mini-grid from constructing a bioreactor. Table 6-5 shows the economic and market potential under these financial and market assumptions.

Table 6-5: Low LFG Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	8,400	8,400	4,200	2,881	0	4,200
2004	8,400	4,200	0	4,057	0	4,200
2005	8,400	4,200	0	4,200	0	4,200
2006	8,400	4,200	0	4,200	0	4,200
2007	8,400	4,200	0	4,200	0	4,200
2008	8,400	4,200	0	4,200	0	4,200
2009	8,400	4,200	0	4,200	0	4,200
2010	8,400	4,200	0	4,200	0	4,200
2011	8,400	4,200	0	4,200	0	4,200
2012	8,400	4,200	0	4,200	0	4,200

<u>*High Scenario*</u>

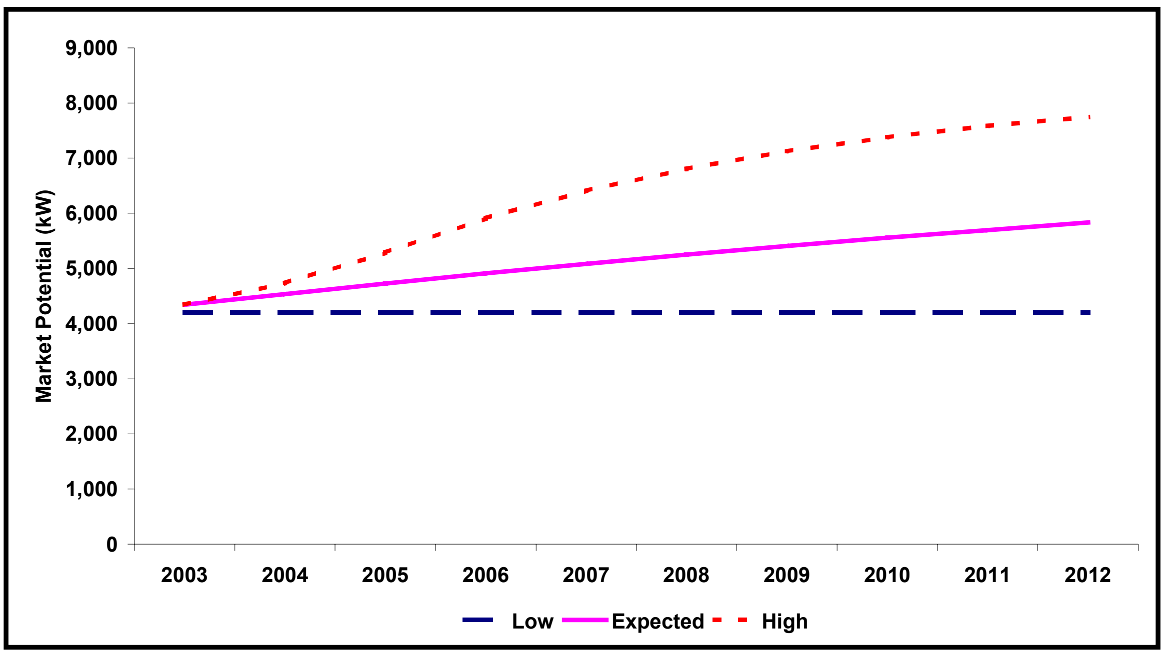
The known projects, the incremental potential, and the cumulative market potential are summarized in Table 6-6.

Table 6-6: High LFG Market Potential

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	8,400	8,400	4,200	2,881	144	4,344
2004	8,400	4,056	0	3,918	392	4,736
2005	8,400	3,664	0	3,664	550	5,285
2006	8,400	3,115	0	3,115	623	5,908
2007	8,400	2,492	0	2,492	498	6,407
2008	8,400	1,993	0	1,993	399	6,805
2009	8,400	1,595	0	1,595	319	7,124
2010	8,400	1,276	0	1,276	255	7,379
2011	8,400	1,021	0	1,021	204	7,584
2012	8,400	816	0	816	163	7,747

The results for all three market potential scenarios are illustrated in Figure 6-3.

Figure 6-3: LFG Market Potential Scenarios



7

Biogas and BI-PV Market Potential Summary

The objectives that were established for the Commonwealth Renewables Mini-Grid Program Planning and Analysis Project, Task 1.1.7, PIER Mini-Grid Biogas and BI-PV Market Potential Assessment, are as follows.

- Estimate the economic potential (MW) for each Commonwealth Program biogas and BI-PV resource in 2003, 2007, and 2012 within the electric system mini-grid.
- Estimate the market potential (MW) for each biogas and BI-PV resource in 2003, 2007, and 2012 within the electric system mini-grid.

This report describes the methodology used to assess the economic and market potential for biogas and BI-PV resources within the PIER mini-grid. More specifically, this assessment addresses nonresidential BI-PV, agricultural and food processing waste biogas, incrementally developed generation capacity from enhanced wastewater treatment biogas, and landfill bioreactor gas resources over the period of 2003 through 2012.

The results of this market potential assessment are summarized in this section. Section 7.1 summarizes the results by scenario. In Section 7.2 the market potential is summarized by resource type, while in Section 7.3 the key market drivers are discussed. The overall conclusions resulting from this work are presented in Section 7.4.

7.1 Summary of Technical, Economic, and Market Potential

The market assessment of biogas and BI-PV resources is conducted under three scenarios. These scenarios include: expected market potential, low market potential, and high market potential. The expected scenario reflects the expected financial and market conditions within the mini-grid. The low scenario reflects what could happen if certain financial conditions, such as state and federal support for renewables, as well as general market conditions were to become less favorable for renewable distributed generation. The high scenario reflects what could happen if financial and market conditions were to become more favorable than currently expected.

The technical potential assessments for each of the renewable resources were performed in earlier Project 1.1 tasks: Task 1.1.2 for dairy and food waste biogas, Task 1.1.3 for landfill gas (LFG), Task 1.1.4 for wastewater treatment (WWT) biogas, and Task 1.1.5 for nonresidential building integrated photovoltaics (BI-PV).

The economic potential assessment involved cash flow modeling of technology prototypes developed to represent those that are likely to be implemented in the Chino Basin as well as those explored in other PIER Commonwealth Projects under the broader PIER Commonwealth research, development and demonstration program. The selected financial measure of performance used in this analysis was the internal rate of return (IRR). The IRR was computed for these prototypes under a number of financial conditions consistent with the three economic and market scenarios. These cash flow analyses results were subsequently fed into the economic hurdle rate model developed for this project to determine the relative portion of the technical potential that is considered economically viable.

The market potential was based on assumptions consistent with the three scenarios. The market penetration rates were dependant on market conditions considered for each scenario.

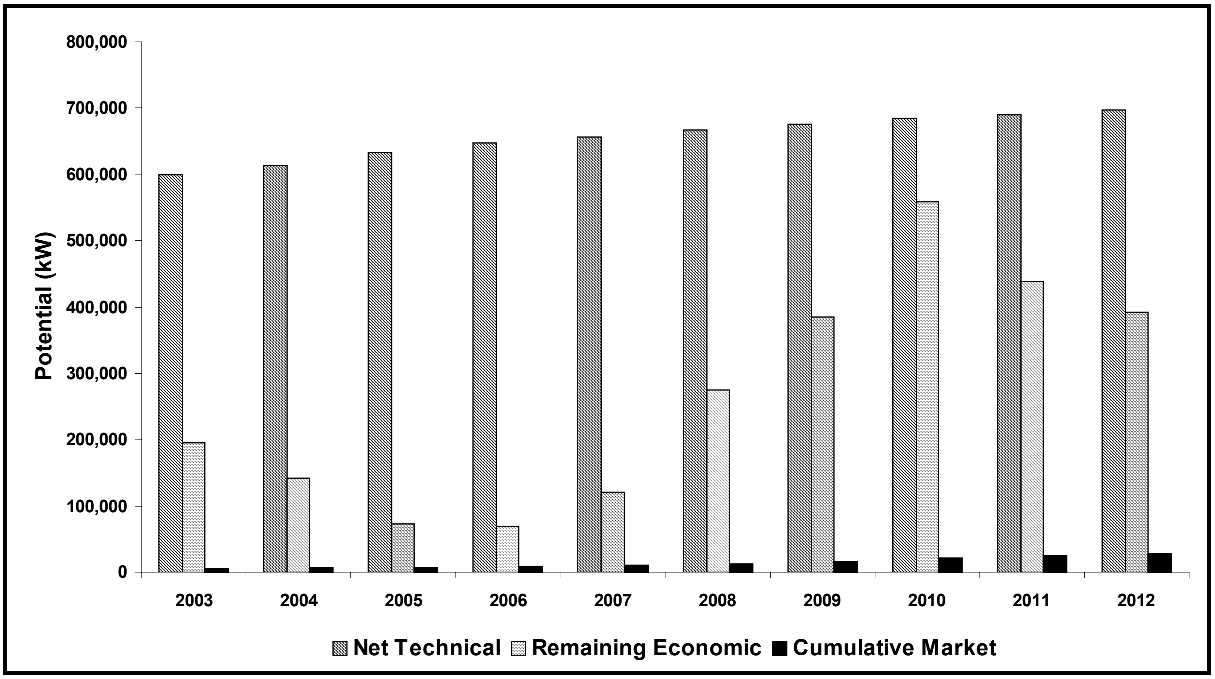
The results of these assessments present a comprehensive picture of the prospects for biogas and BI-PV distributed generation within the defined mini-grid. The results for the expected scenario are summarized in Table 7-1.

Table 7-1: Expected Scenario Potential – Biogas and BI-PV Resources

Year	Gross Technical Potential (kW)	Net Technical Potential (kW)	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	598,842	598,771	4,200	195,426	995	5,263
2004	619,895	614,632	150	141,828	1,260	6,639
2005	639,962	633,472	0	72,634	1,299	7,859
2006	654,521	646,812	0	69,144	957	8,694
2007	665,732	657,188	0	119,977	1,410	9,960
2008	677,422	667,612	0	275,713	2,816	12,588
2009	688,401	675,963	0	385,754	3,820	16,108
2010	700,287	684,329	0	558,473	5,410	21,061
2011	710,544	689,632	0	437,444	4,283	24,663
2012	720,958	696,445	0	392,405	3,899	27,721

In this base scenario, the cumulative market potential for all four of the identified Program renewable resources is 0.9% of the gross technical potential in 2003. This technical potential expected saturation rate grows to 3.8% by 2012. The gross technical potential grows by 20% over this period, whereas the expected cumulative market potential grows by 427%. The results in Table 7-1 are graphically illustrated in Figure 7-1.

Figure 7-1: Expected Scenario Potential – Biogas and BI-PV Resources



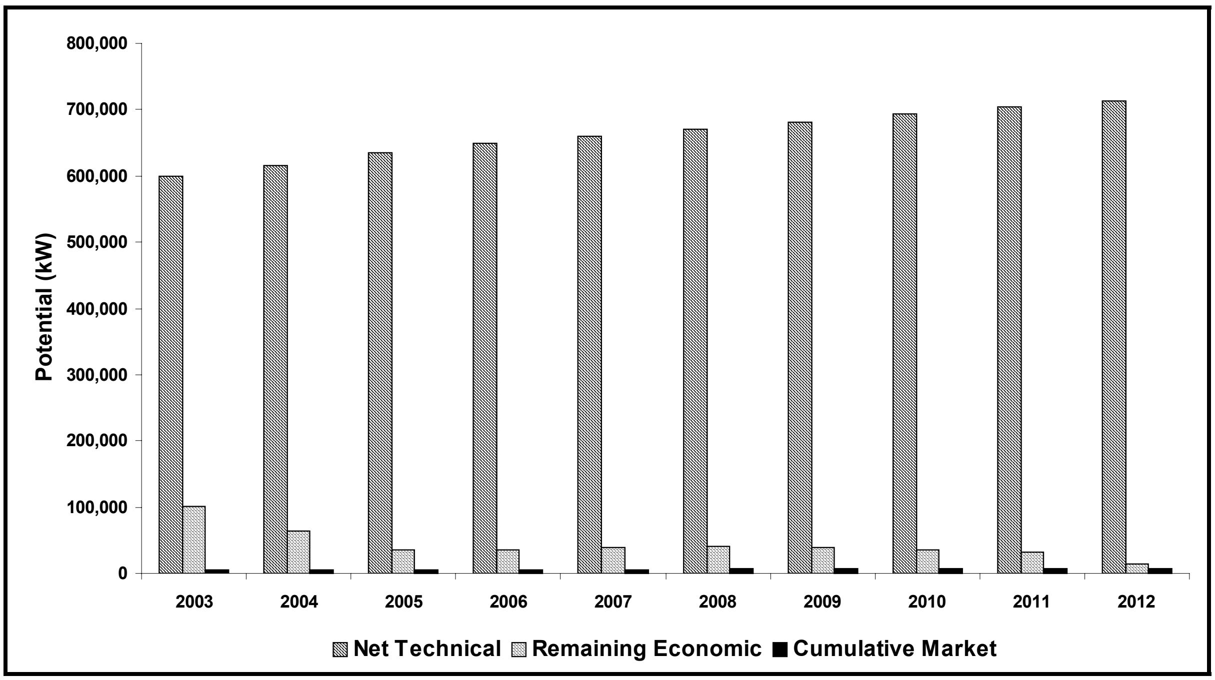
The results for the low scenario projections of market potential of all four resources are summarized in Table 7-2.

Table 7-2: Low Scenario Potential – Biogas and BI-PV Resources

Year	Gross Technical Potential	Net Technical Potential	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	598,842	598,804	4,200	101,061	393	4,630
2004	619,895	615,266	0	64,630	481	5,098
2005	639,962	634,864	0	35,772	432	5,501
2006	654,521	649,020	0	34,782	351	5,806
2007	665,732	659,926	0	39,096	411	6,161
2008	677,422	671,261	0	41,186	439	6,531
2009	688,401	681,870	0	38,143	404	6,855
2010	700,237	693,383	0	35,753	405	7,168
2011	710,494	703,327	0	31,808	360	7,427
2012	720,908	713,482	0	14,492	201	7,521

In this lower than expected scenario, the cumulative market potential is estimated to be 0.8% of the gross technical potential in 2003 and increases to just over 1% by 2012. The results in Table 7-2 are graphically illustrated in Figure 7-2.

Figure 7-2: Low Scenario Potential – Biogas and BI-PV Resources



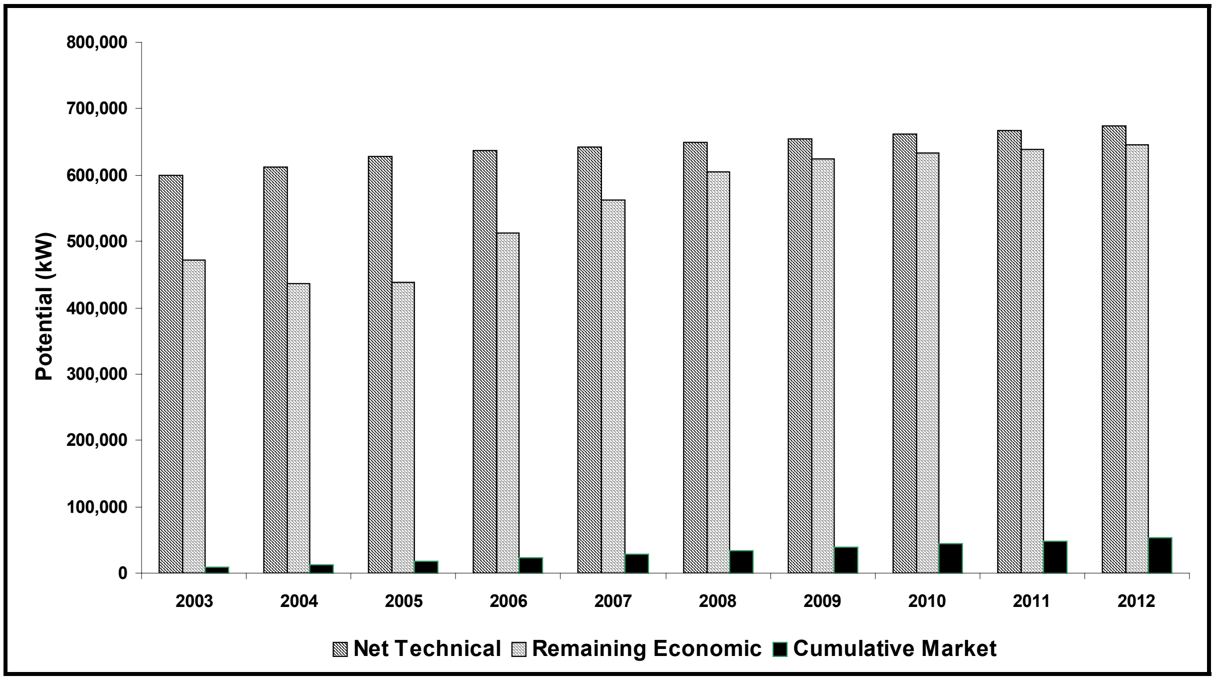
The results for the high scenario projections of market potential of all four resources are summarized in Table 7-3.

Table 7-3: High Scenario Potential – Biogas and BI-PV Resources

Year	Gross Technical Potential	Net Technical Potential	Incremental Known Projects (kW)	Remaining Economic Potential (kW)	Incremental Market Potential (kW)	Cumulative Market Potential (kW)
2003	598,842	598,671	4,200	471,157	3,999	8,362
2004	619,895	611,533	1600	435,818	4,146	12,415
2005	639,962	627,546	0	438,984	6,166	18,348
2006	654,521	636,173	0	512,207	5,589	23,472
2007	665,732	642,272	0	561,493	5,741	28,545
2008	677,422	649,142	0	604,843	6,084	33,745
2009	688,401	655,237	0	624,817	6,216	38,852
2010	700,337	662,380	0	633,206	6,446	43,968
2011	710,594	667,837	0	639,050	6,288	48,711
2012	721,008	673,544	0	645,998	6,332	53,292

In this aggressive "green scenario", the cumulative market potential is 1.4% of the gross technical potential after only five years and is expected to be over 7% by 2012. The results in Table 7-3 are graphically illustrated in Figure 7-3.

Figure 7-3: High Scenario Potential – Biogas and BI-PV Resources



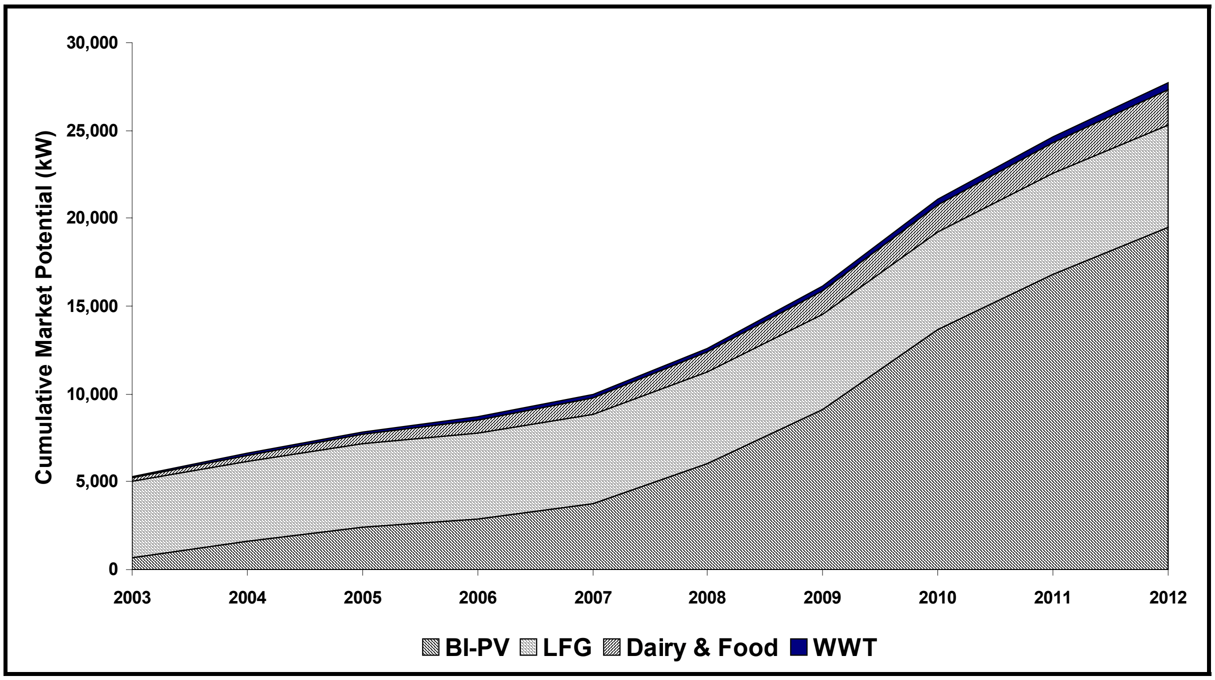
7.2 Summary of Combined Market Potential by Resource

The combined expected market potential for these four nonresidential renewable resources within the Commonwealth Program mini-grid is approximately 5 MW in 2003 and increases to nearly 28 MW by 2012. In the early years, the combined potential is dominated by LFG. By the end of the planning horizon, the BI-PV potential dominates the combined potential. This higher growth impact for BI-PV is illustrated in Table 7-4 and Figure 7-4. The technical potential estimate for this market assessment is based on that portion of the biogas production potential that is over and above the existing level. Again, it must be noted for comparative resource assessment purposes that a very significant portion of the enhanced waste water treatment generation capacity is already interconnected to the electric grid (i.e., 4,960 kW running on either natural gas and/or digester gas). This potential is therefore not included in the totals below – as this "existing generation" does not have a *net impact on the electric distribution system* for the purposes of the power flow studies performed under this planning and analysis project. Since the on-site generation already exists, this resource development impact is viewed simply as *fuel switching* for the electric system power flow analysis performed under Task 1.1.9 b of this Planning and Analysis project.

Table 7-4: Expected Market Potential by Resource

Year	Total (kW)	BI-PV (kW)	LFG (kW)	Dairy & Food Waste (kW)	Incremental WWT (kW)
2003	5,263	685	4,344	167	67
2004	6,639	1,593	4,540	395	111
2005	7,859	2,442	4,733	541	143
2006	8,694	2,885	4,916	726	167
2007	9,960	3,765	5,090	919	186
2008	12,588	6,004	5,256	1,124	204
2009	16,108	9,118	5,413	1,356	221
2010	21,061	13,631	5,563	1,570	298
2011	24,663	16,831	5,704	1,777	351
2012	27,721	19,460	5,839	2,033	389

Figure 7-4: Expected Market Potential by Resource

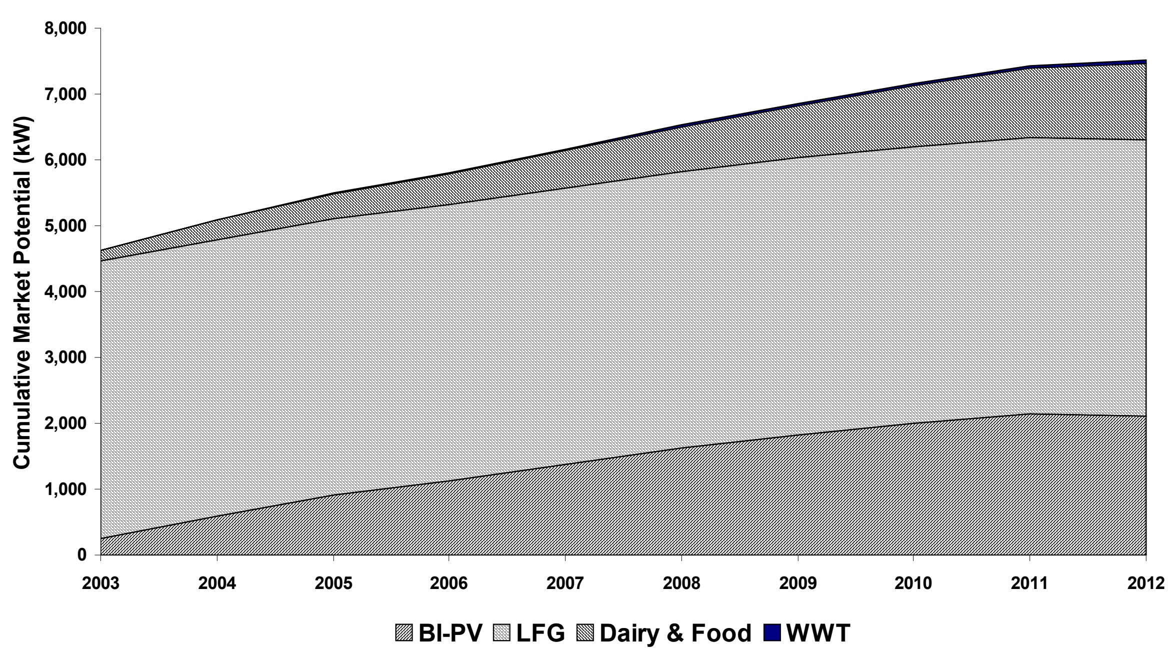


For the combined low market potential scenario, the LFG resource dominates throughout the entire planning horizon. By 2012, BI-PV begins to make a major contribution to the total. The combined market potential in the low scenario only reaches 7.5 MW. This is shown in Table 7-5 and Figure 7-5.

Table 7-5: Low Market Potential by Resource

Year	Total (kW)	BI-PV (kW)	LFG (kW)	Dairy & Food Waste (kW)	Incremental WWT (kW)
2003	4,630	258	4,200	167	4
2004	5,098	585	4,200	305	8
2005	5,501	906	4,200	383	12
2006	5,806	1,124	4,200	467	16
2007	6,161	1,368	4,200	573	20
2008	6,531	1,619	4,200	689	24
2009	6,855	1,830	4,200	797	27
2010	7,168	2,004	4,200	929	35
2011	7,427	2,135	4,200	1,050	42
2012	7,521	2,103	4,200	1,169	49

Figure 7-5: Low Market Potential by Resource

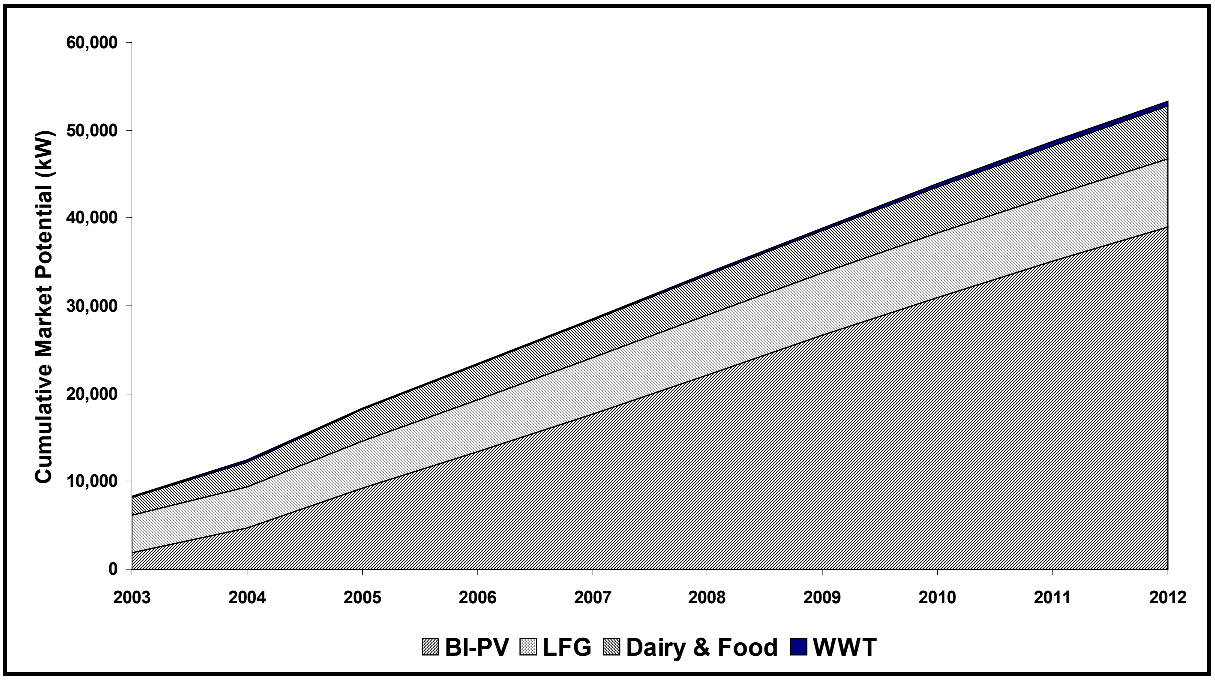


The combined high scenario market potential for the renewable resources within the mini-grid is approximately 8 MW in 2003 and increases to 53 MW by 2012. In the first year the combined potential is dominated by the LFG. By the end of the planning horizon the BI-PV potential dominates the combined potential by a large margin. This is shown in Table 7-6 and Figure 7-6.

Table 7-6: High Market Potential by Resource

Year	Total (kW)	BI-PV (kW)	LFG (kW)	Dairy & Food Waste (kW)	Incremental WWT (kW)
2003	8,362	1,851	4,344	2,017	150
2004	12,415	4,671	4,736	2,833	176
2005	18,348	9,293	5,285	3,580	189
2006	23,472	13,358	5,908	4,005	201
2007	28,545	17,674	6,407	4,252	213
2008	33,745	22,163	6,805	4,547	229
2009	38,852	26,604	7,124	4,879	245
2010	43,968	30,893	7,379	5,255	442
2011	48,711	35,024	7,584	5,627	476
2012	53,292	39,005	7,747	6,046	494

Figure 7-6: High Market Potential by Resource



7.3 Summary of Key Economic and Market Drivers

The key economic and market drivers for each of the four renewable resources differ. For BI-PV, the key economic driver is availability of financial support through utility ratepayer funded public purpose rebate/Buydown programs and tax-related government incentives. Currently in California, these programs play an essential role in reducing costs by an amount necessary to stimulate the markets for this technology on a large scale. Over $100 million dollars of ratepayer funded incentives are currently available for BI-PV systems statewide. Continued availability of such financial support depends on political, regulatory and other circumstances and therefore is uncertain. Consumer level of familiarity with the technology is a key market driver for BI-PV. Currently many consumers are unfamiliar with solar electric distributed generation technology, and may even confuse it with solar thermal technology. The speed with which familiarity and knowledge of the technology and systems increases will be an important determining factor governing future BI-PV deployment.

The potential for landfill bioreactors is heavily driven by the regulatory approval processes and requirements within the local mini-grid region. Even though the market potential assessment was developed under hypothetical conditions, the current permitting requirements may prove to be prohibitive and are the single most important factor in the adoption of this renewable energy resource here and in other areas of California.

For the dairy waste resources, the key economic driver is not so much the capital costs, but rather the environmental benefits accrued from the reduction in reactive organic gases and the reduction in nitrates leaching into the groundwater. These environmental factors proved to have the potential for substantial economic benefits. The unique situation within the mini-grid allows a particular public agency the opportunity to capitalize on many of these benefits. These environmental benefits have the potential to be very large depending on how future environmental credit markets evolve. It is just a question of whether the critical mass of dairies will remain in business long enough for these waste management and energy recovery project benefits to be realized.

The key driver for the food waste resource is the relative economics for the food processing companies in the area. Disposal of the food processing wastes is not the only option available to these firms. Some of the firms have already developed economic alternative uses for the substances within their process waste streams. The most viable option to take advantage of biogas production from these wastes may be to integrate food waste into the wastewater treatment AD systems that already exist.

The potential for enhanced WWT processes to produce additional biogas to energy is driven by the willingness of IEUA, the WWT agency located within the mini-grid, to take advantage of new advancements in anaerobic digestion, energy recovery, and gas cleaning technologies that are being developed. The economics appear to be very favorable given the potential outcomes. The primary risk is in demonstrating the true performance and reliability of these technologies.

7.4 Conclusions

There is a very large technical and economic potential for biogas and non-residential BI-PV distributed generation within the Commonwealth mini-grid. In fact, the total gross technical potential of 599 MW is actually slightly greater than the **entire peak electric load on the distribution system** within the mini-grid itself. At present, the expected market adoption of this potential is not estimated to be very large, in large part due to the fact that nearly 5MW of distributed generation at WWT facilities currently exists that will simply switch its fuel supply over time as biogas resources are developed. In the expected case, this incremental renewable generation that will impact the electric grid is estimated to be less than 4% of the gross technical potential by 2012. In the *aggressive green* or high case scenario, this estimate increases to 7.4% of gross technical potential.

Market adoption of the economic potential for alternative generation has traditionally not been very significant. In order for more of this potential to be adopted within the mini-grid, many market barriers will need to be overcome. Some of these barriers are typical of any relatively new and/or uncommon technologies. Research, development and demonstration projects as well as technology transfer initiatives may help to improve penetration rates. Other barriers are associated with the fact that non-residential establishments, such as the dairies in the basin, are not primarily concerned with their electric costs (or on-site generation) to remain in business. Even if it is economical, it is often considered a distraction from their primary business operations. New ownership models may be necessary to help overcome this market entry barrier.

Publicly supported incentives and educational programs can have an impact on market adoption if they are persistent and are perceived as reliable and part of a longer-term strategy. Continuation of the state's Self-Generation Incentives Program beyond its current term of December 31, 2004 for application submittal would likely have a positive effect on future adoption of both biogas and BI-PV renewable resources within the mini-grid.

The development of environmental emissions credit markets has the potential to monetize the benefits that can be accrued from the reductions in air pollutants, greenhouse gases and groundwater contamination. These various regulatory driven credit markets would make an already economical renewable generation market even more competitive to third party project developers.

Appendix A

Tables of BI-PV Results

This Appendix contains more detailed tables of BI-PV Market Potential results than those presented in the body of the report. The calculations were done separately for different cases, including: public/private sector, small/medium/industrial tariff, and low/average/high market potential. Market potential results for each of the cases were calculated using the approach described in Section 2.5, Market Potential Model Overview. Table A-1 presents formulas used to implement the market potential model. The specific case of expected BI-PV market potential for non-residential medium commercial customers in the private sector is depicted in Table A-1. Formulas presented in Table A-1 are representative of those used to implement the market potential model for other BI-PV cases.

Table A-1: Representative BI-PV Market Potential Model Formulas

	A	B	C	D	E	F	G	H
2	**Year**	**Gross Tech Potential (kW)**	**Net Tech Potential (kW)**	**'ACCEPT' (%)**	**Economic Potential (SOY) (kW)**	**Incremental Market Potential (During Year) (kW)**	**Cumulative Market Potential (end of year) (kW)**	**Cumulative Sales (EOY) (kW)**
3	2002	266145	=B3	0.34268	=D3*C3	=B$16*E3	=F3	=F3
4	2003	=B$3*C17	=B4-G3	0.4519	=D4*C4	=B$17*E4	=G3*(1-Decay)+F4	=G4
5	2004	=B$3*C18	=B5-G4	0.28857	=D5*C5	=B$18*E5	=G4*(1-Decay)+F5	=H4+F5
6	2005	=B$3*C19	=B6-G5	0.11723	=D6*C6	=B$19*E6	=G5*(1-Decay)+F6	=H5+F6
7	2006	=B$3*C20	=B7-G6	0.1012	=D7*C7	=B$20*E7	=G6*(1-Decay)+F7	=H6+F7
8	2007	=B$3*C21	=B8-G7	0.2044	=D8*C8	=B$21*E8	=G7*(1-Decay)+F8	=H7+F8
9	2008	=B$3*C22	=B9-G8	0.62124	=D9*C9	=B$22*E9	=G8*(1-Decay)+F9	=H8+F9
10	2009	=B$3*C23	=B10-G9	0.84368	=D10*C10	=B$23*E10	=G9*(1-Decay)+F10	=H9+F10
11	2010	=B$3*C24	=B11-G10	0.90681	=D11*C11	=B$24*E11	=G10*(1-Decay)+F11	=H10+F11
12	2011	=B$3*C25	=B12-G11	0.85971	=D12*C12	=B$25*E12	=G11*(1-Decay)+F12	=H11+F12
13	2012	=B$3*C26	=B13-G12	0.84669	=D13*C13	=B$26*E13	=G12*(1-Decay)+F13	=H12+F13
14								
15	**Year**	**Market Penetration Rate**	**Tech Potential Growth Factor**					
16	2002	0.0005	1					
17	2003	0.0015	1.0398					
18	2004	0.0045	1.0805					
19	2005	0.009	1.1193					
20	2006	0.009	1.1477					
21	2007	0.009	1.1698					
22	2008	0.009	1.1927					
23	2009	0.009	1.2143					
24	2010	0.009	1.2373					
25	2011	0.009	1.2576					
26	2012	0.009	1.2774					

BI-PV market potential results for each of the cases are presented below.

Table A-2: Total Private & Public Sector Non-Residential BI-PV Market Potential (Expected Potenial)

Small Commercial, Medium Commercial, and Industrial Tariffs. Public & Private, Expected.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	526,039	526,039	142,887	71	71	71
2003	546,975	546,904	189,503	617	685	685
2004	568,366	567,681	135,685	942	1,593	1,627
2005	588,815	587,222	66,462	928	2,442	2,556
2006	603,756	601,314	62,747	565	2,885	3,121
2007	615,349	612,464	113,797	1,024	3,765	4,145
2008	627,416	623,652	269,701	2,427	6,004	6,572
2009	638,773	632,769	379,394	3,415	9,118	9,987
2010	650,886	641,768	552,148	4,969	13,631	14,956
2011	661,521	647,889	431,235	3,881	16,831	18,837
2012	671,962	655,131	385,570	3,470	19,460	22,307

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	36,405	36,405	24,770	12	12	12
2003	37,854	37,842	30,563	46	58	58
2004	39,335	39,277	28,298	127	182	185
2005	40,750	40,568	13,795	124	297	309
2006	41,784	41,487	14,107	127	409	436
2007	42,586	42,177	28,415	256	644	692
2008	43,421	42,777	36,092	325	937	1,017
2009	44,207	43,270	38,502	347	1,237	1,363
2010	45,046	43,809	43,679	393	1,568	1,756
2011	45,782	44,214	42,576	383	1,873	2,139
2012	46,504	44,631	41,189	371	2,150	2,510

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	289,296	289,296	98,372	49	49	49
2003	300,810	300,761	135,071	369	416	416
2004	312,574	312,158	89,261	568	963	983
2005	323,820	322,857	37,005	498	1,413	1,482
2006	332,036	330,623	32,599	293	1,635	1,775
2007	338,412	336,776	67,962	612	2,165	2,387
2008	345,048	342,883	212,118	1,909	3,966	4,296
2009	351,294	347,328	292,018	2,628	6,396	6,924
2010	357,956	351,560	317,768	2,860	8,936	9,784
2011	363,804	354,868	304,045	2,736	11,226	12,520
2012	369,546	358,321	302,334	2,721	13,385	15,241

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	200,338	200,338	19,745	10	10	10
2003	208,311	208,302	23,869	202	212	212
2004	216,458	216,246	18,126	247	449	459
2005	224,246	223,797	15,662	306	732	765
2006	229,936	229,204	16,041	144	840	910
2007	234,351	233,511	17,420	157	955	1,066
2008	238,947	237,992	21,490	193	1,100	1,260
2009	243,272	242,171	48,873	440	1,485	1,700
2010	247,885	246,400	190,702	1,716	3,127	3,416
2011	251,935	248,808	84,615	762	3,732	4,177
2012	255,912	252,179	42,046	378	3,924	4,556

Table A-3: Private Sector Non-Residential BI-PV Market Potential (Expected Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Private, Expected.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	483,943	483,943	27.4%	132,744	66	66	66
2003	503,204	503,138	34.9%	175,725	264	327	327
2004	522,883	522,556	24.1%	126,014	567	877	894
2005	541,696	540,818	11.5%	62,106	559	1,392	1,453
2006	555,440	554,048	10.6%	58,724	529	1,851	1,981
2007	566,106	564,254	18.8%	105,829	952	2,711	2,934
2008	577,208	574,497	43.5%	249,732	2,248	4,823	5,181
2009	587,655	582,832	60.2%	351,023	3,159	7,741	8,340
2010	598,799	591,058	86.3%	510,163	4,591	11,946	12,932
2011	608,583	596,637	66.8%	398,749	3,589	14,937	16,521
2012	618,189	603,252	59.1%	356,674	3,210	17,400	19,731

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	33,492	33,492	68.3%	22,887	11	11	11
2003	34,825	34,814	81.1%	28,221	42	53	53
2004	36,187	36,134	72.3%	26,141	118	168	171
2005	37,489	37,321	34.3%	12,789	115	275	286
2006	38,440	38,165	34.3%	13,079	118	379	404
2007	39,178	38,799	67.6%	26,242	236	596	640
2008	39,947	39,350	84.7%	33,318	300	866	940
2009	40,670	39,803	89.3%	35,536	320	1,143	1,260
2010	41,441	40,298	100.0%	40,298	363	1,448	1,622
2011	42,118	40,670	96.6%	39,284	354	1,729	1,976
2012	42,783	41,053	92.6%	38,009	342	1,985	2,318

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	266,145	266,145	34.3%	91,204	46	46	46
2003	276,738	276,692	45.2%	125,038	188	231	231
2004	287,560	287,329	28.9%	82,917	373	592	604
2005	297,906	297,314	11.7%	34,855	314	877	918
2006	305,465	304,589	10.1%	30,825	277	1,110	1,195
2007	311,330	310,220	20.4%	63,412	571	1,625	1,766
2008	317,436	315,811	62.1%	196,195	1,766	3,310	3,532
2009	323,182	319,872	84.4%	269,872	2,429	5,573	5,960
2010	329,310	323,737	90.7%	293,569	2,642	7,937	8,603
2011	334,691	326,754	86.0%	280,917	2,528	10,068	11,131
2012	339,974	329,906	84.7%	279,329	2,514	12,079	13,645

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	184,306	184,306	10.1%	18,652	9	9	9
2003	191,641	191,632	11.7%	22,466	34	43	43
2004	199,136	199,093	8.5%	16,957	76	117	119
2005	206,301	206,184	7.0%	14,462	130	241	249
2006	211,535	211,294	7.0%	14,820	133	362	382
2007	215,597	215,235	7.5%	16,175	146	490	528
2008	219,825	219,335	9.2%	20,219	182	647	710
2009	223,804	223,157	20.4%	45,615	411	1,025	1,120
2010	228,048	227,023	77.7%	176,295	1,587	2,561	2,707
2011	231,774	229,213	34.3%	78,548	707	3,140	3,414
2012	235,433	232,293	16.9%	39,336	354	3,337	3,768

Table A-4: Public Sector Non-Residential BI-PV Market Potential (Expected Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Public, Expected.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	42,096	42,096	24.1%	10,143	0	5	5	5
2003	43,771	43,766	31.5%	13,778	333	354	358	358
2004	45,483	45,125	21.4%	9,670	333	375	716	734
2005	47,120	46,404	9.4%	4,355	333	370	1,049	1,103
2006	48,315	47,266	8.5%	4,023	0	36	1,033	1,139
2007	49,243	48,210	16.5%	7,968	0	72	1,053	1,211
2008	50,209	49,155	40.6%	19,969	0	180	1,180	1,391
2009	51,117	49,937	56.8%	28,371	0	255	1,377	1,646
2010	52,087	50,710	82.8%	41,985	0	378	1,686	2,024
2011	52,938	51,252	63.4%	32,486	0	292	1,894	2,316
2012	53,773	51,880	55.7%	28,895	0	260	2,059	2,576

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	2,913	2,913	64.6%	1,883	0	1	1	1
2003	3,029	3,028	77.4%	2,343	0	4	4	4
2004	3,148	3,143	68.6%	2,157	0	10	14	14
2005	3,261	3,247	31.0%	1,005	0	9	22	23
2006	3,344	3,321	31.0%	1,028	0	9	30	32
2007	3,408	3,378	64.3%	2,173	0	20	48	52
2008	3,475	3,426	81.0%	2,774	0	25	71	77
2009	3,538	3,467	85.6%	2,966	0	27	94	104
2010	3,605	3,511	96.3%	3,380	0	30	120	134
2011	3,664	3,544	92.9%	3,292	0	30	143	164
2012	3,721	3,578	88.9%	3,180	0	29	165	192

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	23,151	23,151	31.0%	7,168	0	4	4	4
2003	24,072	24,069	41.7%	10,033	167	181	185	185
2004	25,014	24,829	25.6%	6,344	167	194	370	379
2005	25,913	25,543	8.4%	2,150	167	185	536	564
2006	26,571	26,035	6.8%	1,774	0	16	525	580
2007	27,081	26,556	17.1%	4,550	0	41	540	621
2008	27,612	27,072	58.8%	15,923	0	143	656	764
2009	28,112	27,456	80.7%	22,146	0	199	823	963
2010	28,645	27,822	87.0%	24,198	0	218	999	1,181
2011	29,113	28,114	82.3%	23,128	0	208	1,158	1,389
2012	29,573	28,415	81.0%	23,005	0	207	1,307	1,596

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	16,032	16,032	6.8%	1,092	0	1	1	1
2003	16,670	16,669	8.4%	1,403	167	169	169	169
2004	17,322	17,153	6.8%	1,169	167	171	332	340
2005	17,945	17,613	6.8%	1,200	167	176	491	516
2006	18,400	17,909	6.8%	1,220	0	11	478	527
2007	18,754	18,276	6.8%	1,245	0	11	465	538
2008	19,122	18,657	6.8%	1,271	0	11	453	550
2009	19,468	19,015	17.1%	3,258	0	29	460	579
2010	19,837	19,377	74.3%	14,407	0	130	566	709
2011	20,161	19,595	31.0%	6,067	0	55	593	763
2012	20,479	19,886	13.6%	2,710	0	24	587	788

Table A-5: Total Private & Public Sector Non-Residential BI-PV Market Potential (Low Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Private & Public, Low Potential.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	526,039	526,039	76,976	38	38	38
2003	546,975	546,937	95,221	221	258	258
2004	568,366	568,109	58,236	340	585	598
2005	588,815	588,230	30,274	350	906	948
2006	603,756	602,850	29,298	264	1,124	1,211
2007	615,349	614,225	33,366	300	1,368	1,512
2008	627,416	626,048	35,441	319	1,619	1,831
2009	638,773	637,154	32,418	292	1,830	2,122
2010	650,886	649,057	29,549	266	2,004	2,388
2011	661,521	659,517	25,643	231	2,135	2,619
2012	671,962	669,828	8,341	75	2,103	2,694

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	36,405	36,405	16,282	8	8	8
2003	37,854	37,846	19,272	29	37	37
2004	39,335	39,298	13,363	60	95	97
2005	40,750	40,655	3,182	29	119	125
2006	41,784	41,665	2,916	26	139	152
2007	42,586	42,447	2,970	27	159	178
2008	43,421	43,262	3,027	27	178	206
2009	44,207	44,029	3,081	28	197	233
2010	45,046	44,849	3,138	28	215	262
2011	45,782	45,566	3,189	29	233	290
2012	46,504	46,271	3,238	29	251	319

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	289,296	289,296	48,223	24	24	24
2003	300,810	300,786	60,687	130	153	153
2004	312,574	312,421	35,801	200	345	353
2005	323,820	323,474	22,637	243	571	596
2006	332,036	331,465	23,196	209	751	804
2007	338,412	337,661	23,630	213	926	1,017
2008	345,048	344,122	24,082	217	1,097	1,234
2009	351,294	350,197	24,507	221	1,262	1,454
2010	357,956	356,693	24,962	225	1,424	1,679
2011	363,804	362,380	22,455	202	1,555	1,881
2012	369,546	367,992	5,103	46	1,523	1,927

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	200,338	200,338	12,470	6	6	6
2003	208,311	208,305	15,262	62	68	68
2004	216,458	216,390	9,072	80	144	148
2005	224,246	224,101	4,455	79	216	227
2006	229,936	229,720	3,186	29	234	255
2007	234,351	234,117	6,766	61	283	316
2008	238,947	238,664	8,332	75	344	391
2009	243,272	242,928	4,830	43	370	435
2010	247,885	247,515	1,449	13	365	448
2011	251,935	251,570	0	0	346	448
2012	255,912	255,565	0	0	329	448

Table A-6: Private Sector Non-Residential BI-PV Market Potential (Low Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Private, Low Potential.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	483,943	483,943	14.8%	71,771	36	36	36
2003	503,204	503,168	17.6%	88,600	133	167	167
2004	522,883	522,716	10.4%	54,468	245	404	412
2005	541,696	541,292	5.2%	27,971	252	635	664
2006	555,440	554,805	4.9%	27,050	243	847	907
2007	566,106	565,259	5.4%	30,795	277	1,082	1,184
2008	577,208	576,126	5.7%	32,706	294	1,322	1,479
2009	587,655	586,333	5.1%	29,924	269	1,525	1,748
2010	598,799	597,274	4.6%	27,285	246	1,695	1,994
2011	608,583	606,888	3.9%	23,656	213	1,823	2,207
2012	618,189	616,366	1.3%	7,736	70	1,801	2,276

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	33,492	33,492	45.0%	15,068	8	8	8
2003	34,825	34,817	51.2%	17,827	27	34	34
2004	36,187	36,153	34.3%	12,389	56	88	90
2005	37,489	37,401	7.9%	2,961	27	110	116
2006	38,440	38,330	7.0%	2,688	24	129	140
2007	39,178	39,049	7.0%	2,739	25	147	165
2008	39,947	39,799	7.0%	2,792	25	165	190
2009	40,670	40,505	7.0%	2,841	26	182	216
2010	41,441	41,259	7.0%	2,894	26	199	242
2011	42,118	41,919	7.0%	2,940	26	216	268
2012	42,783	42,567	7.0%	2,986	27	232	295

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	266,145	266,145	16.9%	45,069	23	23	23
2003	276,738	276,715	20.4%	56,563	85	106	106
2004	287,560	287,454	11.7%	33,699	152	253	258
2005	297,906	297,653	7.0%	20,877	188	428	446
2006	305,465	305,037	7.0%	21,395	193	599	638
2007	311,330	310,731	7.0%	21,795	196	765	835
2008	317,436	316,671	7.0%	22,211	200	927	1,034
2009	323,182	322,255	7.0%	22,603	203	1,084	1,238
2010	329,310	328,226	7.0%	23,022	207	1,237	1,445
2011	334,691	333,454	6.2%	20,716	186	1,362	1,631
2012	339,974	338,612	1.4%	4,750	43	1,336	1,674

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	184,306	184,306	6.3%	11,635	6	6	6
2003	191,641	191,636	7.4%	14,209	21	27	27
2004	199,136	199,109	4.2%	8,379	38	63	65
2005	206,301	206,237	2.0%	4,133	37	97	102
2006	211,535	211,438	1.4%	2,966	27	119	128
2007	215,597	215,478	2.9%	6,261	56	169	185
2008	219,825	219,656	3.5%	7,703	69	230	254
2009	223,804	223,574	2.0%	4,480	40	259	294
2010	228,048	227,789	0.6%	1,369	12	259	307
2011	231,774	231,516	0.0%	0	0	246	307
2012	235,433	235,187	0.0%	0	0	233	307

Table A-7: Public Sector Non-Residential BI-PV Market Potential (Low Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Public, Low Potential.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	42,096	42,096	12.4%	5,205	0	3	3	3
2003	43,771	43,769	15.1%	6,621	78	88	91	91
2004	45,483	45,393	8.3%	3,768	78	95	181	186
2005	47,120	46,939	4.9%	2,303	78	98	270	284
2006	48,315	48,045	4.7%	2,248	0	20	277	304
2007	49,243	48,966	5.2%	2,571	0	23	286	327
2008	50,209	49,922	5.5%	2,735	0	25	297	352
2009	51,117	50,821	4.9%	2,493	0	22	304	374
2010	52,087	51,783	4.4%	2,263	0	20	309	395
2011	52,938	52,628	3.8%	1,988	0	18	312	413
2012	53,773	53,462	1.1%	606	0	5	302	418

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	2,913	2,913	41.7%	1,214	0	1	1	1
2003	3,029	3,029	47.7%	1,445	0	2	3	3
2004	3,148	3,145	31.0%	974	0	4	7	7
2005	3,261	3,254	6.8%	222	0	2	9	9
2006	3,344	3,335	6.8%	227	0	2	10	11
2007	3,408	3,398	6.8%	232	0	2	12	13
2008	3,475	3,463	6.8%	236	0	2	13	15
2009	3,538	3,524	6.8%	240	0	2	15	18
2010	3,605	3,590	6.8%	245	0	2	16	20
2011	3,664	3,647	6.8%	249	0	2	18	22
2012	3,721	3,704	6.8%	252	0	2	19	24

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	23,151	23,151	13.6%	3,155	0	2	2	2
2003	24,072	24,071	17.1%	4,124	39	45	47	47
2004	25,014	24,967	8.4%	2,101	39	48	93	95
2005	25,913	25,821	6.8%	1,759	39	55	143	150
2006	26,571	26,428	6.8%	1,801	0	16	152	166
2007	27,081	26,929	6.8%	1,835	0	17	161	183
2008	27,612	27,451	6.8%	1,870	0	17	170	199
2009	28,112	27,942	6.8%	1,904	0	17	178	217
2010	28,645	28,467	6.8%	1,940	0	17	187	234
2011	29,113	28,926	6.0%	1,739	0	16	193	250
2012	29,573	29,380	1.2%	353	0	3	187	253

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	16,032	16,032	5.2%	835	0	0	0	0
2003	16,670	16,670	6.3%	1,052	39	41	41	41
2004	17,322	17,281	4.0%	693	39	42	81	83
2005	17,945	17,864	1.8%	322	39	42	119	125
2006	18,400	18,282	1.2%	220	0	2	115	127
2007	18,754	18,639	2.7%	504	0	5	114	131
2008	19,122	19,008	3.3%	629	0	6	114	137
2009	19,468	19,354	1.8%	349	0	3	111	140
2010	19,837	19,726	0.4%	79	0	1	106	141
2011	20,161	20,055	0.0%	0	0	0	101	141
2012	20,479	20,378	0.0%	0	0	0	96	141

Table A-8: Total Private & Public Sector Non-Residential BI-PV Market Potential (High Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Private & Public, High Potential.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	526,039	526,039	343,154	172	172	172
2003	546,975	546,804	459,367	1,688	1,851	1,851
2004	568,366	566,516	426,211	2,913	4,671	4,764
2005	588,815	584,144	429,341	4,855	9,293	9,619
2006	603,756	594,463	503,293	4,530	13,358	14,149
2007	615,349	601,991	553,782	4,984	17,674	19,133
2008	627,416	609,742	596,950	5,373	22,163	24,505
2009	638,773	616,610	616,610	5,549	26,604	30,055
2010	650,886	624,282	624,282	5,619	30,893	35,673
2011	661,521	630,628	630,628	5,676	35,024	41,349
2012	671,962	636,939	636,939	5,732	39,005	47,081

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	36,405	36,405	32,394	16	16	16
2003	37,854	37,838	36,740	55	70	70
2004	39,335	39,264	38,715	174	241	245
2005	40,750	40,509	39,333	354	583	599
2006	41,784	41,201	41,078	370	924	968
2007	42,586	41,662	41,539	374	1,251	1,342
2008	43,421	42,170	42,170	380	1,568	1,722
2009	44,207	42,639	42,639	384	1,874	2,106
2010	45,046	43,172	43,172	389	2,169	2,494
2011	45,782	43,613	43,613	393	2,453	2,887
2012	46,504	44,052	44,052	396	2,726	3,283

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	289,296	289,296	242,637	121	121	121
2003	300,810	300,688	267,558	901	1,016	1,016
2004	312,574	311,558	277,247	1,745	2,710	2,761
2005	323,820	321,109	277,075	2,989	5,564	5,750
2006	332,036	326,472	308,540	2,777	8,063	8,527
2007	338,412	330,349	318,159	2,863	10,523	11,391
2008	345,048	334,525	334,525	3,011	13,008	14,401
2009	351,294	338,286	338,286	3,045	15,402	17,446
2010	357,956	342,554	342,554	3,083	17,715	20,529
2011	363,804	346,089	346,089	3,115	19,944	23,644
2012	369,546	349,603	349,603	3,146	22,093	26,790

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	200,338	200,338	68,123	34	34	34
2003	208,311	208,277	155,068	732	764	764
2004	216,458	215,694	110,250	994	1,720	1,758
2005	224,246	222,526	112,933	1,512	3,146	3,270
2006	229,936	226,790	153,674	1,383	4,372	4,653
2007	234,351	229,979	194,085	1,747	5,900	6,400
2008	238,947	233,047	220,255	1,982	7,587	8,382
2009	243,272	235,685	235,685	2,121	9,329	10,503
2010	247,885	238,556	238,556	2,147	11,009	12,650
2011	251,935	240,926	240,926	2,168	12,627	14,819
2012	255,912	243,284	243,284	2,190	14,185	17,008

Table A-9: Private Sector Non-Residential BI-PV Market Potential (High Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Private, High Potential.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	483,943	483,943	65.5%	317,070	159	159	159
2003	503,204	503,045	84.3%	424,098	636	787	787
2004	522,883	522,096	75.5%	394,263	1,774	2,522	2,561
2005	541,696	539,174	73.8%	397,676	3,579	5,975	6,140
2006	555,440	549,466	84.9%	466,647	4,200	9,876	10,340
2007	566,106	556,230	92.3%	513,213	4,619	14,001	14,959
2008	577,208	563,207	98.0%	551,977	4,968	18,269	19,927
2009	587,655	569,387	100.0%	569,387	5,124	22,480	25,051
2010	598,799	576,320	100.0%	576,320	5,187	26,543	30,238
2011	608,583	582,040	100.0%	582,040	5,238	30,454	35,476
2012	618,189	587,735	100.0%	587,735	5,290	34,221	40,766

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	33,492	33,492	89.3%	29,901	15	15	15
2003	34,825	34,810	97.4%	33,903	51	65	65
2004	36,187	36,122	98.9%	35,724	161	223	226
2005	37,489	37,266	97.4%	36,295	327	538	552
2006	38,440	37,902	100.0%	37,902	341	852	894
2007	39,178	38,326	100.0%	38,326	345	1,155	1,239
2008	39,947	38,792	100.0%	38,792	349	1,446	1,588
2009	40,670	39,224	100.0%	39,224	353	1,727	1,941
2010	41,441	39,714	100.0%	39,714	357	1,998	2,298
2011	42,118	40,120	100.0%	40,120	361	2,259	2,659
2012	42,783	40,524	100.0%	40,524	365	2,511	3,024

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	266,145	266,145	84.2%	224,010	112	112	112
2003	276,738	276,626	89.3%	246,967	370	477	477
2004	287,560	287,083	89.3%	256,304	1,153	1,606	1,630
2005	297,906	296,300	86.6%	256,516	2,309	3,835	3,939
2006	305,465	301,630	94.8%	285,914	2,573	6,216	6,512
2007	311,330	305,114	96.6%	294,720	2,652	8,558	9,165
2008	317,436	308,878	100.0%	308,878	2,780	10,910	11,944
2009	323,182	312,272	100.0%	312,272	2,810	13,175	14,755
2010	329,310	316,136	100.0%	316,136	2,845	15,361	17,600
2011	334,691	319,330	100.0%	319,330	2,874	17,467	20,474
2012	339,974	322,506	100.0%	322,506	2,903	19,496	23,377

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	184,306	184,306	34.3%	63,159	32	32	32
2003	191,641	191,610	74.7%	143,227	215	245	245
2004	199,136	198,891	51.4%	102,236	460	693	705
2005	206,301	205,608	51.0%	104,864	944	1,602	1,649
2006	211,535	209,933	68.0%	142,830	1,285	2,807	2,934
2007	215,597	212,790	84.7%	180,168	1,622	4,288	4,556
2008	219,825	215,537	94.8%	204,306	1,839	5,913	6,394
2009	223,804	217,891	100.0%	217,891	1,961	7,578	8,355
2010	228,048	220,470	100.0%	220,470	1,984	9,183	10,340
2011	231,774	222,591	100.0%	222,591	2,003	10,728	12,343
2012	235,433	224,705	100.0%	224,705	2,022	12,214	14,365

Table A-10: Public Sector Non-Residential BI-PV Market Potential (High Potential)

Small Commercial, Medium Commercial, and Industrial Tariffs. Public, High Potential.

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	42,096	42,096	62.0%	26,084	0	13	13	13
2003	43,771	43,758	80.6%	35,269	1,000	1,051	1,064	1,064
2004	45,483	44,419	71.9%	31,948	1,000	1,139	2,150	2,203
2005	47,120	44,970	70.4%	31,665	1,000	1,276	3,318	3,479
2006	48,315	44,997	81.4%	36,646	0	330	3,482	3,809
2007	49,243	45,761	88.7%	40,569	0	365	3,673	4,174
2008	50,209	46,535	96.6%	44,974	0	405	3,894	4,579
2009	51,117	47,223	100.0%	47,223	0	425	4,125	5,004
2010	52,087	47,962	100.0%	47,962	0	432	4,350	5,435
2011	52,938	48,588	100.0%	48,588	0	437	4,570	5,873
2012	53,773	49,204	100.0%	49,204	0	443	4,784	6,316

Small Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	2,913	2,913	85.6%	2,493	0	1	1	1
2003	3,029	3,028	93.7%	2,837	0	4	5	5
2004	3,148	3,142	95.2%	2,991	0	13	19	19
2005	3,261	3,242	93.7%	3,038	0	27	45	46
2006	3,344	3,299	96.3%	3,176	0	29	71	75
2007	3,408	3,337	96.3%	3,213	0	29	97	104
2008	3,475	3,378	100.0%	3,378	0	30	122	134
2009	3,538	3,415	100.0%	3,415	0	31	147	165
2010	3,605	3,458	100.0%	3,458	0	31	171	196
2011	3,664	3,493	100.0%	3,493	0	31	194	227
2012	3,721	3,528	100.0%	3,528	0	32	216	259

Medium Commercial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	23,151	23,151	80.5%	18,627	0	9	9	9
2003	24,072	24,063	85.6%	20,591	500	530	539	539
2004	25,014	24,475	85.6%	20,943	500	592	1,104	1,131
2005	25,913	24,809	82.9%	20,559	500	681	1,729	1,812
2006	26,571	24,842	91.1%	22,626	0	204	1,847	2,015
2007	27,081	25,235	92.9%	23,439	0	211	1,965	2,226
2008	27,612	25,647	100.0%	25,647	0	231	2,098	2,457
2009	28,112	26,014	100.0%	26,014	0	234	2,227	2,691
2010	28,645	26,418	100.0%	26,418	0	238	2,353	2,929
2011	29,113	26,760	100.0%	26,760	0	241	2,477	3,170
2012	29,573	27,096	100.0%	27,096	0	244	2,597	3,414

Industrial Tariff

Year	Gross Tech Potential (SOY) (kW)	Net Tech Potential (SOY) (kW)	Acceptance Rate (%)	Economic Potential (SOY) (kW)	Identified Projects (kW)	Incremental Market Potential (During Year) (kW)	Cumulative Market Potential (EOY) (kW)	Cumulative Sales (EOY) (kW)
2002	16,032	16,032	31.0%	4,964	0	2	2	2
2003	16,670	16,668	71.0%	11,841	500	517	519	519
2004	17,322	16,803	47.7%	8,014	500	534	1,027	1,053
2005	17,945	16,918	47.7%	8,069	500	568	1,544	1,621
2006	18,400	16,857	64.3%	10,844	0	98	1,564	1,719
2007	18,754	17,189	81.0%	13,917	0	125	1,611	1,844
2008	19,122	17,510	91.1%	15,949	0	144	1,674	1,988
2009	19,468	17,793	100.0%	17,793	0	160	1,751	2,148
2010	19,837	18,086	100.0%	18,086	0	163	1,826	2,311
2011	20,161	18,335	100.0%	18,335	0	165	1,900	2,476
2012	20,479	18,579	100.0%	18,579	0	167	1,972	2,643

Appendix B

Tables of Biogas Results

This Appendix contains more detailed tables of Biogas Market Potential results than those presented in the body of the report. The calculations were done separately for different cases, including: public/private sector and low/average/high market potential. Market potential results for each of the cases were calculated using the approach described in Section 2.5, Market Potential Model Overview. Table B-1 presents formulas used to implement the market potential model.

Table B-1: Representative Biogas Market Potential Model Formulas

	B	C	D	E	F	G	H	I	J
14	Year	Gross Tech Potential	Net Tech Potential	"Accept"	Incremental Known Projects	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
15	2003	8,400	=C15	84.3%	4,200	=E15*D15-F15	=MPF*G15	=H15	=I15+F15
16	2004	8,400	=C16-J15	96.6%	0	=E16*D16-F16	=MPF*G16	=I15*(1-Decay)+H16	=J15+H16
17	2005	8,400	=C17-J16	100.0%	0	=E17*D17-F17	=MPF*G17	=I16*(1-Decay)+H17	=J16+H17
18	2006	8,400	=C18-J17	100.0%	0	=E18*D18-F18	=MPF*G18	=I17*(1-Decay)+H18	=J17+H18
19	2007	8,400	=C19-J18	100.0%	0	=E19*D19-F19	=MPF*G19	=I18*(1-Decay)+H19	=J18+H19
20	2008	8,400	=C20-J19	100.0%	0	=E20*D20-F20	=MPF*G20	=I19*(1-Decay)+H20	=J19+H20
21	2009	8,400	=C21-J20	100.0%	0	=E21*D21-F21	=MPF*G21	=I20*(1-Decay)+H21	=J20+H21
22	2010	8,400	=C22-J21	100.0%	0	=E22*D22-F22	=MPF*G22	=I21*(1-Decay)+H22	=J21+H22
23	2011	8,400	=C23-J22	100.0%	0	=E23*D23-F23	=MPF*G23	=I22*(1-Decay)+H23	=J22+H23
24	2012	8,400	=C24-J23	100.0%	0	=E24*D24-F24	=MPF*G24	=I23*(1-Decay)+H24	=J23+H24

MPF = Market Penetration Factor
Decay = Technology Decay Rate

Biogas market potential results for each of the cases are presented below.

Table B-2: Total Landfill Gas Potential (Expected Case)

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Incremental Known Projects	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	8,400	8,400	84%	4,200	2,881	144	144	4,344
2004	8,400	4,056	97%	0	3,918	196	340	4,540
2005	8,400	3,860	100%	0	3,860	193	533	4,733
2006	8,400	3,667	100%	0	3,667	183	716	4,916
2007	8,400	3,484	100%	0	3,484	174	890	5,090
2008	8,400	3,310	100%	0	3,310	165	1,056	5,256
2009	8,400	3,144	100%	0	3,144	157	1,213	5,413
2010	8,400	2,987	100%	0	2,987	149	1,363	5,563
2011	8,400	2,837	100%	0	2,837	142	1,504	5,704
2012	8,400	2,696	100%	0	2,696	135	1,639	5,839

Table B-3: Total Landfill Gas Potential (High Case)

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Incremental Known Projects	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	8,400	8,400	84%	4,200	2,881	144	144	4,344
2004	8,400	4,056	97%	0	3,918	392	536	4,736
2005	8,400	3,664	100%	0	3,664	550	1,085	5,285
2006	8,400	3,115	100%	0	3,115	623	1,708	5,908
2007	8,400	2,492	100%	0	2,492	498	2,207	6,407
2008	8,400	1,993	100%	0	1,993	399	2,605	6,805
2009	8,400	1,595	100%	0	1,595	319	2,924	7,124
2010	8,400	1,276	100%	0	1,276	255	3,179	7,379
2011	8,400	1,021	100%	0	1,021	204	3,384	7,584
2012	8,400	816	100%	0	816	163	3,547	7,747

Table B-4: Total Land Fill Gas Potential (Low Case)

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Incremental Known Projects	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	8,400	8,400	84%	4,200	2,881	0	0	4,200
2004	8,400	4,200	97%	0	4,057	0	0	4,200
2005	8,400	4,200	100%	0	4,200	0	0	4,200
2006	8,400	4,200	100%	0	4,200	0	0	4,200
2007	8,400	4,200	100%	0	4,200	0	0	4,200
2008	8,400	4,200	100%	0	4,200	0	0	4,200
2009	8,400	4,200	100%	0	4,200	0	0	4,200
2010	8,400	4,200	100%	0	4,200	0	0	4,200
2011	8,400	4,200	100%	0	4,200	0	0	4,200
2012	8,400	4,200	100%	0	4,200	0	0	4,200

Table B-5: Total Wastewater Treatment Biogas Potential (Expected Case)

Total WWT

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	167	167	100%	0	167	67	67	67
2004	179	112	100%	0	112	45	111	111
2005	190	79	100%	0	79	32	143	143
2006	202	59	100%	0	59	24	167	167
2007	214	47	100%	0	47	19	186	186
2008	231	45	100%	0	45	18	204	204
2009	247	43	100%	0	43	17	221	221
2010	413	192	100%	0	192	77	298	298
2011	430	132	100%	0	132	53	351	351
2012	446	95	100%	0	95	38	389	389

Prototype #1 - Enhansed Biogas and Generation Production

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	167	167	100.0%		167	67	67	67
2004	179	112	100.0%		112	45	111	111
2005	190	79	100.0%		79	32	143	143
2006	202	59	100.0%		59	24	167	167
2007	214	47	100.0%		47	19	186	186
2008	231	45	100.0%		45	18	204	204
2009	247	43	100.0%		43	17	221	221
2010	263	42	100.0%		42	17	238	238
2011	280	42	100.0%		42	17	255	255
2012	296	41	100.0%		41	17	271	271

Prototype #2 - New Generation for Growth

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	0	0	0.0%		0	0	0	0
2004	0	0	0.0%		0	0	0	0
2005	0	0	0.0%		0	0	0	0
2006	0	0	0.0%		0	0	0	0
2007	0	0	0.0%		0	0	0	0
2008	0	0	0.0%		0	0	0	0
2009	0	0	0.0%		0	0	0	0
2010	150	150	100.0%		150	60	60	60
2011	150	90	100.0%		90	36	96	96
2012	150	54	100.0%		54	22	118	118

Table B-6: Total Wastewater Treatment Biogas Potential (High Case)

Total WWT

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	167	167	100%	0	167	150	150	150
2004	179	29	100%	0	29	26	176	176
2005	190	15	100%	0	15	13	189	189
2006	202	13	100%	0	13	12	201	201
2007	214	13	100%	0	13	12	213	213
2008	231	18	100%	0	18	16	229	229
2009	247	18	100%	0	18	16	245	245
2010	463	218	100%	0	218	196	442	442
2011	480	38	100%	0	38	34	476	476
2012	496	20	100%	0	20	18	494	494

Prototype #1 - Enhansed Biogas and Generation Production

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	167	167	100.0%		167	150	150	150
2004	179	29	100.0%		29	26	176	176
2005	190	15	100.0%		15	13	189	189
2006	202	13	100.0%		13	12	201	201
2007	214	13	100.0%		13	12	213	213
2008	231	18	100.0%		18	16	229	229
2009	247	18	100.0%		18	16	245	245
2010	263	18	100.0%		18	16	262	262
2011	280	18	100.0%		18	16	278	278
2012	296	18	100.0%		18	16	294	294

Prototype #2 - New Generation for Growth

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	0	0	0.0%		0	0	0	0
2004	0	0	0.0%		0	0	0	0
2005	0	0	0.0%		0	0	0	0
2006	0	0	0.0%		0	0	0	0
2007	0	0	0.0%		0	0	0	0
2008	0	0	0.0%		0	0	0	0
2009	0	0	0.0%		0	0	0	0
2010	200	200	100.0%		200	180	180	180
2011	200	20	100.0%		20	18	198	198
2012	200	2	100.0%		2	2	200	200

Table B-7: Total Wastewater Treatment Biogas Potential (Low Case)

Total WWT

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2,003	167	167	50%	0	84	4	4	4
2,004	179	174	42%	0	74	4	8	8
2,005	190	183	42%	0	77	4	12	12
2,006	202	191	42%	0	80	4	16	16
2,007	214	198	42%	0	84	4	20	20
2,008	231	211	35%	0	73	4	24	24
2,009	247	223	35%	0	77	4	27	27
2,010	363	336	44%	0	147	7	35	35
2,011	380	345	41%	0	142	7	42	42
2,012	396	354	41%	0	144	7	49	49

Prototype #1 - Enhansed Biogas and Generation Production

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2,003	167	167	50.1%		84	4	4	4
2,004	179	174	42.2%		74	4	8	8
2,005	190	183	42.2%		77	4	12	12
2,006	202	191	42.2%		80	4	16	16
2,007	214	198	42.2%		84	4	20	20
2,008	231	211	34.6%		73	4	24	24
2,009	247	223	34.6%		77	4	27	27
2,010	263	236	34.6%		82	4	31	31
2,011	280	248	34.6%		86	4	36	36
2,012	296	260	34.6%		90	4	40	40

Prototype #2 - New Generation for Growth

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	0	0	0.0%		0	0	0	0
2004	0	0	0.0%		0	0	0	0
2005	0	0	0.0%		0	0	0	0
2006	0	0	0.0%		0	0	0	0
2007	0	0	0.0%		0	0	0	0
2008	0	0	0.0%		0	0	0	0
2009	0	0	0.0%		0	0	0	0
2010	100	100	65.6%		66	3	3	3
2011	100	97	58.0%		56	3	6	6
2012	100	94	58.0%		54	3	9	9

Table B-8: Total Food Processing Waste Biogas Potential (Expected Case)

Total Ag & Food Process Waste Centralized AD

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	37,000	37,000	7%	0	2,457	0	0	0
2004	37,000	37,000	5%	0	1,968	20	20	20
2005	37,000	36,980	5%	0	1,966	39	59	59
2006	37,000	36,941	6%	0	2,388	72	131	131
2007	37,000	36,869	7%	0	2,406	96	227	227
2008	37,000	36,773	7%	0	2,450	123	349	349
2009	37,000	36,651	8%	0	2,967	148	498	498
2010	37,000	36,502	8%	0	2,983	149	647	647
2011	37,000	36,353	9%	0	3,109	155	802	802
2012	37,000	36,198	11%	0	3,890	194	997	997

Mkt Share 0.2

#1 - Ag & Food Process Waste Centralized AD - Privately Owned

Year	Gross Tech Potential (kW)	Net Tech Potential (kW)	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	7,400	7,400	0.0%		0	0	0	0
2004	7,400	7,400	0.2%		15	0	0	0
2005	7,400	7,400	0.2%		15	0	0	0
2006	7,400	7,400	0.2%		15	0	1	1
2007	7,400	7,399	0.2%		15	1	1	1
2008	7,400	7,399	0.4%		30	1	3	3
2009	7,400	7,397	0.4%		30	1	4	4
2010	7,400	7,396	0.6%		44	2	7	7
2011	7,400	7,393	1.3%		96	5	11	11
2012	7,400	7,389	1.7%		126	6	18	18

Mkt Share 0.4

#2 - Ag & Food Process Waste Centralized AD - Owned by Public Entity & offsets electric purchases

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	14,800	14,800	16.4%		2,427	0	0	0
2004	14,800	14,800	13.0%		1,924	19	19	19
2005	14,800	14,781	13.0%		1,921	38	58	58
2006	14,800	14,742	16.1%		2,374	71	129	129
2007	14,800	14,671	16.1%		2,362	94	223	223
2008	14,800	14,577	16.2%		2,361	118	341	341
2009	14,800	14,459	19.7%		2,848	142	484	484
2010	14,800	14,316	19.7%		2,820	141	625	625
2011	14,800	14,175	19.9%		2,821	141	766	766
2012	14,800	14,034	24.4%		3,424	171	937	937

Mkt Share 0.4

#4 - Ag & Food Process Waste Centralized AD - Owned by Public Entity & electricity sold wholesale

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	14,800	14,800	0.2%		30	0	0	0
2004	14,800	14,800	0.2%		30	0	0	0
2005	14,800	14,800	0.2%		30	1	1	1
2006	14,800	14,799	0.0%		0	0	1	1
2007	14,800	14,799	0.2%		30	1	2	2
2008	14,800	14,798	0.4%		59	3	5	5
2009	14,800	14,795	0.6%		89	4	9	9
2010	14,800	14,791	0.8%		118	6	15	15
2011	14,800	14,785	1.3%		192	10	25	25
2012	14,800	14,775	2.3%		340	17	42	42

Table B-9: Total Food Processing Waste Biogas Potential (High Case)

Total Ag & Food Process Waste Centralized AD

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	37,000	37,000	10%	0	3,700	0	0	0
2004	37,000	37,000	10%	0	3,715	37	37	37
2005	37,000	36,963	12%	0	4,311	86	123	123
2006	37,000	36,877	14%	0	5,108	153	277	277
2007	37,000	36,723	14%	0	5,100	204	481	481
2008	37,000	36,519	16%	0	5,877	294	774	774
2009	37,000	36,226	18%	0	6,589	329	1,104	1,104
2010	37,000	35,896	21%	0	7,418	371	1,475	1,475
2011	37,000	35,525	21%	0	7,349	367	1,842	1,842
2012	37,000	35,158	23%	0	8,201	410	2,252	2,252

Mkt Share 0.2

Ag & Food Process Waste Centralized AD - Privately Owned

Year	Gross Tech Potential (kW)	Net Tech Potential (kW)	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	7,400	7,400	0.0%		0	0	0	0
2004	7,400	7,400	0.2%		15	0	0	0
2005	7,400	7,400	0.2%		15	0	0	0
2006	7,400	7,400	0.2%		15	0	1	1
2007	7,400	7,399	0.2%		15	1	1	1
2008	7,400	7,399	0.4%		30	1	3	3
2009	7,400	7,397	0.4%		30	1	4	4
2010	7,400	7,396	1.1%		81	4	9	9
2011	7,400	7,391	1.3%		96	5	13	13
2012	7,400	7,387	2.3%		170	8	22	22

Mkt Share 0.4

Ag & Food Process Waste Centralized AD - Owned by Public Entity & offsets electric purchases

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	14,800	14,800	24.8%		3,670	0	0	0
2004	14,800	14,800	24.8%		3,670	37	37	37
2005	14,800	14,763	28.9%		4,267	85	122	122
2006	14,800	14,678	34.5%		5,064	152	274	274
2007	14,800	14,526	34.6%		5,026	201	475	475
2008	14,800	14,325	40.2%		5,759	288	763	763
2009	14,800	14,037	46.1%		6,471	324	1,086	1,086
2010	14,800	13,714	52.1%		7,145	357	1,444	1,444
2011	14,800	13,356	52.2%		6,972	349	1,792	1,792
2012	14,800	13,008	58.9%		7,662	383	2,175	2,175

Mkt Share 0.4

Ag & Food Process Waste Centralized AD - Owned by Public Entity & electricity sold wholesale

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	14,800	14,800	0.2%		30	0	0	0
2004	14,800	14,800	0.2%		30	0	0	0
2005	14,800	14,800	0.2%		30	1	1	1
2006	14,800	14,799	0.2%		30	1	2	2
2007	14,800	14,798	0.4%		59	2	4	4
2008	14,800	14,796	0.6%		89	4	9	9
2009	14,800	14,791	0.6%		89	4	13	13
2010	14,800	14,787	1.3%		192	10	23	23
2011	14,800	14,777	1.9%		281	14	37	37
2012	14,800	14,763	2.5%		369	18	55	55

Table B-10: Total Food Processing Waste Biogas Potential (Low Case)

Total Ag & Food Process Waste Centralized AD

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	37,000	37,000	7%	0	2,457	0	0	0
2004	37,000	37,000	5%	0	1,968	20	20	20
2005	37,000	36,980	3%	0	1,079	22	41	41
2006	37,000	36,959	3%	0	1,077	32	74	74
2007	37,000	36,926	4%	0	1,311	52	126	126
2008	37,000	36,874	4%	0	1,350	68	194	194
2009	37,000	36,806	4%	0	1,345	67	261	261
2010	37,000	36,739	5%	0	1,746	87	348	348
2011	37,000	36,652	5%	0	1,736	87	435	435
2012	37,000	36,565	5%	0	1,726	86	521	521

Mkt Share 0.2

Ag & Food Process Waste Centralized AD - Privately Owned

Year	Gross Tech Potential (kW)	Net Tech Potential (kW)	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	7,400	7,400	0.0%		0	0	0	0
2004	7,400	7,400	0.2%		15	0	0	0
2005	7,400	7,400	0.0%		0	0	0	0
2006	7,400	7,400	0.0%		0	0	0	0
2007	7,400	7,400	0.0%		0	0	0	0
2008	7,400	7,400	0.2%		15	1	1	1
2009	7,400	7,399	0.2%		15	1	2	2
2010	7,400	7,398	0.2%		15	1	2	2
2011	7,400	7,398	0.2%		15	1	3	3
2012	7,400	7,397	0.2%		15	1	4	4

Mkt Share 0.4

Ag & Food Process Waste Centralized AD - Owned by Public Entity & offsets electric purchases

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	14,800	14,800	16.4%		2,427	0	0	0
2004	14,800	14,800	13.0%		1,924	19	19	19
2005	14,800	14,781	7.3%		1,079	22	41	41
2006	14,800	14,759	7.3%		1,077	32	73	73
2007	14,800	14,727	8.9%		1,311	52	126	126
2008	14,800	14,674	8.9%		1,306	65	191	191
2009	14,800	14,609	8.9%		1,300	65	256	256
2010	14,800	14,544	11.7%		1,702	85	341	341
2011	14,800	14,459	11.7%		1,692	85	426	426
2012	14,800	14,374	11.7%		1,682	84	510	510

Mkt Share 0.4

Ag & Food Process Waste Centralized AD - Owned by Public Entity & electricity sold wholesale

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	14,800	14,800	0.2%		30	0	0	0
2004	14,800	14,800	0.2%		30	0	0	0
2005	14,800	14,800	0.0%		0	0	0	0
2006	14,800	14,800	0.0%		0	0	0	0
2007	14,800	14,800	0.0%		0	0	0	0
2008	14,800	14,800	0.2%		30	1	2	2
2009	14,800	14,798	0.2%		30	1	3	3
2010	14,800	14,797	0.2%		30	1	5	5
2011	14,800	14,795	0.2%		30	1	6	6
2012	14,800	14,794	0.2%		30	1	8	8

Table B-11: Total Dairy Waste Biogas Potential (Expected Case)

Total Ag Centralized AD

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	6,100	6,100	7%	0	405	162	162	162
2004	5,753	5,591	2%	150	135	54	216	366
2005	5,421	5,205	5%	0	261	104	320	470
2006	5,103	4,783	6%	0	280	112	433	583
2007	4,800	4,367	6%	0	247	99	531	681
2008	4,511	3,980	5%	0	219	87	619	769
2009	4,237	3,618	6%	0	228	91	710	860
2010	3,977	3,267	6%	0	195	78	788	938
2011	3,731	2,943	6%	0	174	70	858	1,008
2012	3,500	2,642	7%	0	185	74	932	1,082

Mkt Share 0.2
Ag Centralized AD - Privately Owned

Year	Gross Tech Potential (kW)	Net Tech Potential (kW)	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	1,220	1,220	0.0%		0	0	0	0
2004	1,151	1,151	0.2%		2	1	1	1
2005	1,084	1,083	0.2%		2	1	2	2
2006	1,021	1,019	0.2%		2	1	3	3
2007	960	957	0.2%		2	1	3	3
2008	902	899	0.4%		4	1	5	5
2009	847	843	0.4%		3	1	6	6
2010	795	789	0.6%		5	2	8	8
2011	746	738	1.3%		10	4	12	12
2012	700	688	1.7%		12	5	17	17

Mkt Share 0.4
Ag Centralized AD - Owned by Public Entity & offsets electric purchases

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	2,440	2,440	16.4%		400	160	160	160
2004	2,301	2,141	13.0%	150	128	51	211	361
2005	2,168	1,957	13.0%		254	102	313	463
2006	2,041	1,728	16.1%		278	111	424	574
2007	1,920	1,496	16.1%		241	96	521	671
2008	1,804	1,284	16.2%		208	83	604	754
2009	1,695	1,091	19.7%		215	86	690	840
2010	1,591	901	19.7%		177	71	761	911
2011	1,492	732	19.9%		146	58	819	969
2012	1,400	581	24.4%		142	57	876	1,026

Mkt Share 0.4
Ag Centralized AD - Owned by Public Entity & electricity sold wholesale

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Known Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential w/o known (end of year)	Total Cumulative Market Potential (end of year)
2003	2,440	2,440	0.2%		5	2	2	2
2004	2,301	2,299	0.2%		5	2	4	4
2005	2,168	2,165	0.2%		4	2	6	6
2006	2,041	2,036	0.0%		0	0	6	6
2007	1,920	1,914	0.2%		4	2	7	7
2008	1,804	1,797	0.4%		7	3	10	10
2009	1,695	1,685	0.6%		10	4	14	14
2010	1,591	1,577	0.8%		13	5	19	19
2011	1,492	1,473	1.3%		19	8	27	27
2012	1,400	1,373	2.3%		32	13	39	39

Table B-12: Total Dairy Waste Biogas Potential (High Case)

Total Ag Centralized AD

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	6,100	6,100	80%	0	4,882	1,953	1,953	1,953
2004	5,753	3,800	49%	800	1,853	741	2,694	3,494
2005	5,421	2,727	60%	0	1,647	659	3,353	4,153
2006	5,103	1,750	42%	0	734	294	3,647	4,447
2007	4,800	1,153	17%	0	201	80	3,727	4,527
2008	4,511	897	1%	0	5	2	3,729	4,529
2009	4,237	840	1%	0	5	2	3,731	4,531
2010	3,977	786	2%	0	13	5	3,736	4,536
2011	3,731	732	2%	0	17	7	3,743	4,543
2012	3,500	679	4%	0	24	10	3,753	4,553

Mkt Share 0.2
Ag Centralized AD - Privately Owned

Year	Gross Tech Potential (kW)	Net Tech Potential (kW)	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	1,220	1,220	0.2%		2	1	1	1
2004	1,151	1,150	0.2%		2	1	2	2
2005	1,084	1,082	0.2%		2	1	3	3
2006	1,021	1,018	0.2%		2	1	4	4
2007	960	956	0.4%		4	2	5	5
2008	902	897	0.6%		5	2	7	7
2009	847	840	0.6%		5	2	9	9
2010	795	786	1.7%		13	5	15	15
2011	746	732	2.3%		17	7	21	21
2012	700	679	3.5%		24	10	31	31

Mkt Share 0.4
Ag Centralized AD - Owned by Public Entity & offsets electric purchases

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	2,440	2,440	100.0%		2,440	976	976	976
2004	2,301	1,325	100.0%	800	525	210	1,186	1,986
2005	2,168	982	100.0%		982	393	1,579	2,379
2006	2,041	462	100.0%		462	185	1,764	2,564
2007	1,920	156	100.0%		156	62	1,826	2,626
2008	1,804	0	100.0%		0	0	1,826	2,626
2009	1,695	0	100.0%		0	0	1,826	2,626
2010	1,591	0	100.0%		0	0	1,826	2,626
2011	1,492	0	100.0%		0	0	1,826	2,626
2012	1,400	0	100.0%		0	0	1,826	2,626

Mkt Share 0.4
Ag Centralized AD - Owned by Public Entity & electricity sold wholesale

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	2,440	2,440	100.0%		2,440	976	976	976
2004	2,301	1,325	100.0%		1,325	530	1,506	1,506
2005	2,168	662	100.0%		662	265	1,771	1,771
2006	2,041	270	100.0%		270	108	1,879	1,879
2007	1,920	41	100.0%		41	16	1,895	1,895
2008	1,804	0	100.0%		0	0	1,895	1,895
2009	1,695	0	100.0%		0	0	1,895	1,895
2010	1,591	0	100.0%		0	0	1,895	1,895
2011	1,492	0	100.0%		0	0	1,895	1,895
2012	1,400	0	100.0%		0	0	1,895	1,895

Table B-13: Total Dairy Waste Biogas Potential (Low Case)

Total Ag Centralized AD

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	6,100	6,100	7%	0	405	162	162	162
2004	5,753	5,591	5%	0	285	114	276	276
2005	5,421	5,145	3%	0	138	55	332	332
2006	5,103	4,771	3%	0	125	50	382	382
2007	4,800	4,418	3%	0	137	55	437	437
2008	4,511	4,074	3%	0	128	51	488	488
2009	4,237	3,749	3%	0	113	45	533	533
2010	3,977	3,444	4%	0	130	52	585	585
2011	3,731	3,146	4%	0	112	45	629	629
2012	3,500	2,871	3%	0	96	38	668	668

Mrk Share 0.2

Ag Centralized AD - Privately Owned

Year	Gross Tech Potential (kW)	Net Tech Potential (kW)	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	1,220	1,220	0.0%		0	0	0	0
2004	1,151	1,151	0.2%		2	1	1	1
2005	1,084	1,083	0.0%		0	0	1	1
2006	1,021	1,020	0.0%		0	0	1	1
2007	960	959	0.0%		0	0	1	1
2008	902	901	0.2%		2	1	2	2
2009	847	846	0.2%		2	1	2	2
2010	795	793	0.2%		2	1	3	3
2011	746	743	0.2%		1	1	4	4
2012	700	696	0.2%		1	1	4	4

Mrk Share 0.4

Ag Centralized AD - Owned by Public Entity & offsets electric purchases

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	2,440	2,440	16.4%		400	160	160	160
2004	2,301	2,141	13.0%		278	111	271	271
2005	2,168	1,897	7.3%		138	55	327	327
2006	2,041	1,714	7.3%		125	50	377	377
2007	1,920	1,543	8.9%		137	55	432	432
2008	1,804	1,373	8.9%		122	49	481	481
2009	1,695	1,214	8.9%		108	43	524	524
2010	1,591	1,067	11.7%		125	50	574	574
2011	1,492	919	11.7%		107	43	617	617
2012	1,400	783	11.7%		92	37	653	653

Mrk Share 0.4

Ag Centralized AD - Owned by Public Entity & electricity sold wholesale

Year	Gross Tech Potential	Net Tech Potential	"Accept"	Cumulative Identifiable Potential	Economic Potential (beg. Of Year)	Incremental Market Potential (during Year)	Cumulative Market Potential (end of year)	Total Cumulative Market Potential (end of year)
2003	2,440	2,440	0.2%		5	2	2	2
2004	2,301	2,299	0.2%		5	2	4	4
2005	2,168	2,165	0.0%		0	0	4	4
2006	2,041	2,037	0.0%		0	0	4	4
2007	1,920	1,916	0.0%		0	0	4	4
2008	1,804	1,801	0.2%		4	1	5	5
2009	1,695	1,690	0.2%		3	1	7	7
2010	1,591	1,584	0.2%		3	1	8	8
2011	1,492	1,485	0.2%		3	1	9	9
2012	1,400	1,391	0.2%		3	1	10	10